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ORGANIZATION AND THE INDIVIDUAL

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This is a period in Industry when there are preponderant advantages in large organizations. At the same time there is also a feeling among a certain class of men, particularly young men preparing for the race and older men who have not found themselves, that organization and the individual are inimical. It is not questioned that there is outward evidence, indeed too much of it, to fortify a dissatisfied mind in this impression, especially when a large view is taken (1) of the rapid rise of these big companies, (2) the fact that they are perforce made up of MEN, and (3) that there are only too often five-thousand-dollar men in ten-thousand-dollar places with all the consequent narrow vision, selfishness and straining for result.

It may be useful therefore at times to get into the mountains to clarify the vision and to see the large outlines of things in their right perspective. When one analyzes this word—organization—it is found to be made up primarily of "organ" which refers to the individual—a function or instrument peculiarly fitted for a certain work or use. And a practical study of this subject will lend a strange emphasis in all its aspects upon this fundamental—The Individual.

Organizing is the art and science of fitting organs each particularly meant for certain functions into a sympathetic and co-ordinated force for a definite larger purpose with a proper provision for its constant renewal. Art and science are used advisedly: *Art* because it will always be an art to deal wisely with the human elements involved; and *science* because in dealing with functions it is becoming more and more a science to design the best form of organzation for each business and the peculiar set of

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conditions of each company. The science lies in the proper laying out of the functions of a work so that each in the performance of its peculiar task promotes the objects of the whole; the art lies in the mind and spirit in applying the proper human beings and to them the necessary discipline and stimulation.

This is the WORK of the organizer, whether his province be great or small. The IDEAL of his work is an ORGANISM—the unit of properly integrated individuals made self-perpetuating. The PATTERN for his efforts lies about him (to surfeit the imagination) in the various expressions of the Great Organizer in Heaven, Earth and Sea. The POSSIBILITIES among men are ready for the taking in the piled-up History and Biography of the world.

One of the best studies in this subject is the human body; its striking individualism with its perfect functionings frequently used in Holy Writ to expound the proper workings of that greatest organization of men—The Church. But in Church or State, in War or Industry, the elements of the subject are the same—*Individuality, Co-ordination, Perpetuation* and *Inspiration;* and it will be noted that the remarks following will build themselves around this skeleton. In taking the measure of an organizer, account must be made of his application of these four hidden elements to the external elements of his problem. To use the nomenclature of Industry there must always be *Manufacturing,* Distribution or *Sales, Treasury* and *Accounting Divisions;* call them by different names, if you please, when the activity be Education or Politics or Social Life, but the use of Industry's phrases in the language of the other walks and vice versa shows that the same elements pervade all fields. It has been remarked that an organization can be designed like a machine and its blueprint made; in such an analysis these four divisons become the fundamental functons regardless of the business or industry under consideration. It is true that in a very small company where you have just two big men the old form was to divide into just two main functions—Factory and Office; but as such a company grows the second soon unfolds into Accounting, Sales and Treasury. It is really in the subdivision of these four main functions that the best thought of the times is changing and in

the manipulation of them that the organizer proves himself at once artist and scientist.

The organizer must first analyze the subfunctions of the Manufacturing, Sales, Treasury and Accounting divisions to fit the industry to which a particular corporation belongs—Metalworking, Woodworking, Chemical, Textile, etc. These subfunctions must be so divided or combined as to give the minimum cross purposes; as for instance, in a basically chemical industry the superintendent must not be the only one to know the product or he holds the company by the throat. A healthy balance requires a Chemical Department to determine and control the product, the superintendent being the operating executive in the making of the product. This illustrates but one of a dozen similarly vital problems in co-ordination.

The organizer is now confronted with the human equation: for this chart of functions and subfunctions—What men have I got? What is their size? What are their possibilities of growth? Where can I get others—and his whole original analysis has then to be re-adjusted on account of what can never be eliminated—the Individual. Co-ordination requires that no one, or several, functions dominate the whole; the balancing of forces means even and healthy progress; but the problem is not an abstract or theoretical one of mere design, but one dependent upon the human material. Certain functions are closely related, so that when a man big enough is found they do well to be combined. The older-fashioned position of Master-mechanic divides itself in a modern metalworking company, for instance, into Works Engineering, as regards the buildings and housing of the processes and their maintenance, and Production Engineering as relates to the mechanical producing equipment. But the latter, in its late development of time study, motion study, speeds and feeds study, routing study, progressive layout of machines and departments is also closely related to the modern Planning or Order Department, which should specify the material, follow it up, store it, schedule it to the departments and machines and into Finished Stock, handle all the clerical records and analyses connected therewith. Consequently under a man with one combination of abilities the two first functions can be thrown together; whereas in recognition of an executive of a mechanical

order the latter two can be profitably combined. Only the highlights can be touched to show how much the individual counts.

Again, the larger an organization grows the less possible it becomes for an executive to get into the details. If it did not kill the Manager physically it would at least seriously damage the company in withdrawing the proper attention from the large problems. Consequently certain combinations must be made giving a few clear functions of Control. Such departments form the railroad tracks for the guidance of the locomotive force. On these the management depends as upon a particular conscience; on the principle of putting all the eggs into one basket and watching the basket, by the proper design and support of the Engineering Department the Manager controls the Determination of the Product; of the Inspection Department he controls the Quality of the Product; of the Accounting Department the Control of Disposition of Funds; by a proper budget system the Control by anticipation of Funds Required; by an Order System or Planning Department for both Manufacturing and Sales a Control like the human nervous system of the motor activities of the organization, in regard to its schedules, materials, deliveries and such like. In this connection the Individual assumes a new importance over that contributed by ability or adaptablity in this added requirement of character.

Various other means are being studied and worked out for developing the Individual, and at the same time co-ordinating the force. Charts of organization are good for definition, but the boundaries they define must be considered as chalk-lines, and not fences, barriers or kingdoms. It is not enough that each Department face forward; they must face forward and inward—in other words, Focus upon the company purpose. But carefully developed charts and the right kind of titles are great preventives of friction.

The whole question of Centralization versus Decentralization in corporation management, aside from the bearing upon it of the geographical location of a number of plants and the necessity of an open labor market, is one largely of how much of the benefits of Centralization does the management wish to pay for the development of individual initiative in Decentralization.

A still more serious problem in the growth of large organizations is the necessity with executive men for creating a *Staff,* such as Assistant to the President or Vice-President, Assistant to the Manufacturing Manager, Assistant to the Sales Director, etc. The very nature of the work of Staff men often creates antagonism in the Line. They are the men that have to do the large thinking, not infrequently, in collecting all aspects of a big subject for their superior; yet they can be permitted no direct authority downward except as they speak as the mouthpiece for their superior. Consequently if they are dynamic men they sooner or later get to the point where they feel their possibilities of action are entirely submerged in the requirements of thought and they resign; or else they acquiesce and surrender to their surroundings, only to become little more than a secretary. The Line usually has the preference in promotions. The great question of co-ordination here is, How can staff men be given proper recognition and latitude?

Co-ordination (which in one sense is really subordination) is often temporarily benefitted by *Committees.* Misunderstanding department heads can often be brought to understand one another, where the men themselves are basically right, by being thrown into a closer working relation for an immediate object by this device. The great trouble with committees, however, is the tendency to investigate and report and do no more. The committee form of company government is like the regency in the State—uncertain and unsatisfactory; and standing committees usually stand in the way.

It is probable that the remarkable accomplishment of the Germans in organization is due to their striking combination of character in the individual, with docility in the mass resulting in their unusual blending of effort and unity of purpose. From the corporation standpoint the ideal is not the co-operation of colorless individuals, but of strong characters mixed with a certain unselfishness and self-discipline.

In the idea of organization self-perpetuation is often omitted. If a correct type is found in the human body which is constantly changing its cells, so that once in every seven years it is entirely renewed, we must consider an organization as never

static. The right kind of human beings are never satisfied, and organization must take this fundamental constantly into account. This means not only the supplying of an understudy for department heads and officials, but the proper stimulation of the human material right from the bottom up. Great advance has been made in this aspect in the last fifty years. Stimulate wage systems and other forms of bonus have been applied to Manufacturing, Office and Sales work. Employees' life insurance and pensions, in addition to general welfare work, recreation clubs, student and apprentice courses have all contributed, together with sanitary surroundings, improvement in lighting, etc., to make men more interested in their work and their particular company. The importance of the Individual has had striking recognition in the development of the employment departments and systems, often including as they now do physical examination, phrenological examination, hospital departments, welfare work, employees' loan funds and such like.

One of the latest developments in this connection is what might be called the Labor Court; a device being operated in one of the large automobile companies, so that no workman can leave the employ without a hearing of his case and thorough examination of how he might be particularly useful elsewhere in the company. This endeavors, first, to go right to the foundation of employment relations in giving plain justice, and, second, attempts to get men in their right places. There has yet to be developed, however, a distinct Promotion system whereby in addition to the study of men and study of a company's activities is carefully worked out for the recognition of men's peculiar combination of abilities and defects. We also need in America proper employment insurance, having insurance now for practically every other hazard of human life. In this Germany is in the lead.

Necessarily a number of activities connected with co-ordination bear also upon perpetuation; likewise those affecting perpetuation bear on the phase called inspiration. The principal reason for referring to this phase as inspiration instead of stimulation lies again in the necessity of recognizing the Individual: The problem as a company increases in size is not only

the stimulation of its men all along the line, but the projection of the spirit of the man at the top to all the outlying departments; on the other hand the powers and individuality of the workman or salesman at the bottom should be brought in touch with the management. There must necessarily be an increasing amount of machinery between them, and this absorbs a tremendous amount of human power, looking at the transmission of force in either direction. The man at the top feels keenly the need for each individual's doing his allotted part, and its effect upon his own sucess as their leader. He feels just as keenly the tremendous vital energy necessary to impart his own unifying vision, his imagination, his force, his insight, to the far confines of the organization. A proper understanding of the manager's position is bound to make better men. The pathetic dependence upon the individual is again evident from the top to the bottom. To go back to our type—we have built up the human body, to complete it we must add a great spirit. When *a great mind animates an organization it gradually becomes an institution;* and the last tribute to the Individual in its relation to the Organization must be by quotation from Carlyle, describing an institution as "no more than the lengthened shadow of a MAN."

All this study of organization is leading to new concepions in business. In addition to the great vertical functions in Manufacturng, Distribution, Treasury and Accounting, five horizontal functons are arising to increasing importance, as worthy each one of special study: *Men, Methods, Money, Machinery, and Materials*—with Men first. The Great War is crystallizing the need for special attention in these horizontal functions, challenging the very fundamentals of our scheme of things. As a result the whole image of an organization as a pyramid is being found too stationary and a newer conception of a great fabric with warp and woof in the making, designed for certain good qualities of strength war, flexibility and beauty, is taking its place.

INTERIOR STANDPIPES AND HOSE SYSTEMS

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There is now a feeling among fire protection engineers that a well designed, properly equipped, and reliably maintained standpipe system affords a valuable and important adjunct to public fire-fighting equipment, especially in the high buildings in large cities. The need for and the great value of an adequate standpipe installation is seldom appreciated by the architect or the owner. While it is true that the standpipe system lacks that essential qualification which has made the automatic sprinkler system such a success, namely, the automatic application of water directly upon the seat of the fire no matter where the fire may have started within the building; yet the standpipe installation is capable of furnishing a class of service of which the sprinkler system is incapable. Next to the automatic sprinkler system, a good standpipe system is the best means for the extinguishment of fire in buildings.

Years ago, standpipe and hose systems were installed not so much to afford reliable protection, but rather to fulfil the requirements of a building ordinance or to afford a means whereby a reduction in insurance rates could be obtained. In most instances the design and installation of the equipments were relegated to an ordinary plumber in a haphazard fashion, they were provided with almost worthless equipment, and very little attempt was made to maintain them in serviceable condition. As a result of such carelessness, standpipe and hose systems had fallen into disrepute, little attention being paid to them by property owners and officials, and in some of the larger cities the fire departments paid little or no attention to the system, disconnecting the hose provided and attaching their own hose and equipment.

The need for properly designed and well-equipped standpipe installations was made manifest as far back as the early nineties. It was realized that new facilities for fighting fire in the many-

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storied buildings, then being built in the larger American cities, were necessary as the equipment of the municipal fire departments could not be relied upon to successfully cope with fires above about from eighty to one hundred feet.

The Home Life Building of New York, a building sixteen stories high and thought at the time to be thoroughly fire-proof, burned on December 4, 1988, and was completely destroyed above the eighth story. The New York Fire Department possessed the most up-to-date apparatus of the day, but the firemen found it impossible to obtain sufficient pressure and volume of water with their equipment to fight the fire above the eighth story.

Mr. W. C. Robinson, Chief Engineer of Underwriters' Laboratories, in a report to the New York Board of Fire Underwriters on the fire which destroyed the Parker Building on the night of January 10, 1908, and which demonstrated that portable fire department apparatus were inefficient for fires established in buildings above the ninth floor, states:

"So far as I am aware, this is the first case on record where a so-called fire-proof building and its contents have been so extensively damaged by a fire starting within the building. Such an occurrence in the largest city in the country, and in a district receiving the full protection of a supposedly well equipped and efficient fire department, was generally unexpected. That the destruction of such a building is not only possible, but quite probable, makes it imperative that requirements for the introduction of necessary safeguards be provided and vigorously enforced.

The Parker Building is understood to be fairly representative of fire-proof buildings occupied for mercantile and light manufacturing purposes in New York City, and is said to have been of even better construction than many later buildings. Its practical destruction, while surprising to the general public, furnishes no reason for the discredit of fire-resisting building construction, and teaches no lessons to the fire protection engineers which have not been more or less understood. The results of this fire do, however, serve to emphasize the necessity for better design, for the more effective use of the materials employed in fireproofing, and for efficient inside fire protection in high buildings."

The fire which destroyed the Equitable Building of New York on January 9, 1912, also demonstrated that public fire departments are unable to effectively fight fires which have gained headway in upper stories of high buildings which are not provided with adequate standpipe equipment. This fire, however, was fought by means of streams taken from standpipes located in about ten neighboring buildings and proved the value of such installations. Mr. F. J. Stewart, Superintendent of the New York Board of Fire Underwriters, in his report on this fire states:

"The extent to which the standpipes were used in the numerous tall buildings facing the Equitable Building across narrow streets, shows a laudable realization on the part of the fire department of the futility of fighting fires above fifty feet, or the fourth story, by hose streams directed from the streets, especially during a high wind."

The classes of service for which an interior standpipe and hose system may be utilized are as follows:

1. For the control of incipient fires.

Small fires, before they have gained headway, can be very easily controlled by the use of small hose streams in charge of occupants of the buildings during the day time, and by watchmen during the night and on holidays.

2. To furnish high-power streams for fire-department use.

During the more advanced stages of a fire, a standpipe equipment should provide all that the municipal fire department would use to fight a fire on the inside of a building for a long time, at least, after the fire starts. As pointed out on the preceding pages, a standpipe system is practically the only means, outside of automatic apparatus, of furnishing high-power streams in the upper stories of high buildings, and to also apply the water directly to the fire in the shortest space of time.

3. To fight fires in nearby buildings.

The latter is probably the greatest value of an efficient standpipe system. While not only providing protection within the building itself, the greatest use of the system is in the event of a conflagration where the tall buildings equipped with standpipes may be used as a bulwark to check the progress of the fire.

The four essentials necessary for a complete interior standpipe and hose system are: a supply of water; the installation of the pipes, fittings, valves, and hose; proper maintenance; and a squad of men who are trained to make use of the facilities provided.

Water Supply

Inasmuch as the stream from a standpipe system is used on a fire in its first stages, it is important that after the line of hose is laid and the valve opened, that a serviceable water pressure should be obtained at once. The success of any standpipe equipment is, therefore, dependent principally upon a water supply of sufficient capacity and adequate pressure. The factors upon which the size of the water supply depends are the size and number of fire streams which are likely to be required and the length of time which these streams will be operated. These factors are influenced by the conditions in the building to be equipped. For large and relatively important buildings the water supplies provided should be of sufficient capacity to supply all of the fire streams needed for the full protection of the building in which the system is installed, the water for the purpose of fighting fires in neighboring buildings being obtained from public five departments or other outside sources. In smaller and relatively unimportant buildings the water supply should be capable of supplying first aid streams for comparatively short periods of time, connections being provided from outside sources for the large streams.

Sources of water supply may be divided into two general classes, viz., those within the building, provided and controlled by the owner; and those without the building which are owned and controlled by the city, or other outside parties. The inside sources of water supply include the gravity tank, the pressure tank, and local or private fire pumps. Domestic city water supply, city fire engines, and high pressure water systems constitute the outside sources.

In nearly every case a standpipe system should be provided with at least two independent water supply sources. One of these sources should be automatic and should be capable of supplying the first-aid streams until the second source can be

brought into action. The second source of supply should be capable of furnishing the heavy calibre streams required for the full protection of the building for an indefinite period of time.

The elevated gravity tank is probably the most common and the oldest source of water supply. The tank should be elevated to such a height as to provide good working pressure at the highest hose station, which would probably mean that the bottom of the tank be at least 20 feet above the roof of the building. The tank should be of liberal capacity, at least 5,000 gallons, and in cases where the tank is used for domestic purposes as well as to supply the standpipe it should be made larger and the connections should be so arranged that the excess supply can only be used for domestic purposes.

In the higher buildings gravity pressures are such at the lower stories as to render it almost impracticable to use the hose. It is, therefore, necessary to provide some means of accomplishing this feature, and it may be of interest to describe the means provided to secure a controllable nozzle pressure at the lower stories in the Singer Building in New York City.

The building is divided into a number of vertical sections, each section having a tank supply of its own. As shown by Fig. 1, a 3,000-gallon gravity tank is installed on the 42nd floor and supplies hose connections placed on the 38th, 39th, and 40th floors through a 4-inch standpipe or riser. On the 39th floor, a 7,000-gallon tank is placed and it supplies the hose connections on all the floors from the 37th to the 26th, inclusive, by means of a 6-inch riser from a 5,000-gallon tank placed on the 27th floor. All of the floors from the 12th to the basement are supplied by three 20,000-gallon tanks through 6-inch risers. It will be noted from this description that the hose connection on the floors immediately below each tank is supplied by the riser from the next upper section, in this manner sufficient pressure being furnished each hose connection.

The tanks are filled by means of four 500-gallon pumps from a large suction tank which is located in the basement. To prevent the fire engines from filling and overflowing the tanks from the risers, a check valve, looking downwardly is placed beneath each tank. To also give each tank a protection from the tank

above and to allow the fire engine to fill the risers clear to the top of the building, check valves, opening upwardly, are installed at the foot of each riser at the point just before it connects to the lower riser.

The same tanks which supply the standpipe system are also used for house service, and in order to assure a constant supply of water for fire service, the house pipes were extended up into the tanks a certain distance, while the fire risers were connected to the bottom of the tanks. Thus permitting the fire risers to draw all the contents of the tanks, while the house lines can only draw as much water as is above the tops of the pipes.

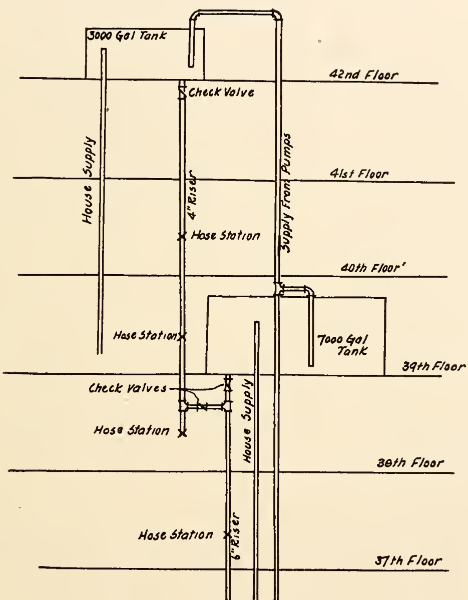

Fig. 1—Arrangement of Pressure Tanks in Singer Building.

The pressure tank, as a source of water supply, is advantageous where pressure is more important than volume. It can be located inside the building on the upper story, it is not unduly

heavy or excessively large and, inasmuch as it is air-tight, there is practically no evaporation and it does not require frequent filling. In cases where the tank is located on the roof of the building, it is necessary that it be enclosed in a tank house and properly protected from freezing. The capacity of the tanks vary from 4,500 gallons to 9,000 gallons, or larger. They are generally kept about two-thirds full of water, the other third being under air pressure supplied from a steam or electrically-driven air compressor. Pressures of about 75 pounds per square inch are maintained in these tanks at all times.

Fire pumps, either steam or electric, properly designed and installed, form one of the most reliable and satisfactory systems of water supply. Property owners very often consider a separate fire pump a costly and burdensome safeguard, and, unless it is required by law, the pump used for the house water-supply is also relied upon to perform the duty of the fire pump. Gravity tanks are very quickly emptied and, since the outside sources of water supply cannot always be expected to perform the duty expected of them, fire pumps are necessary to an efficient standpipe system, especially so during the time of a conflagration or while the fire department is responding to an alarm. Either type of fire pump should be built and installed in accordance with the National Standard Specifications as compiled by the National Fire Protection Association.

Domestic city water supply is so common and so well-known as to need no special comment here. This source of supply is generally at such a low pressure that when connected to a standpipe it is of hardly any service, excepting in buildings of only moderate height.

In large fires, where large amounts of water are required for long intervals of time, public fire departments are, in nearly all cases, depended upon to furnish the water for the standpipe systems. The connections for the fire engine supply are located on the outside of the building near the sidewalk and are either of the single or the Siamese pattern, being installed in a horizontal position with the outlets pointing slightly downward. Each connection is provided with female couplings of the proper size and thread to fit the fire department hose. In order to distin-

guish the standpipe service from the automatic or open sprinkler supplies, a metal sign reading, "Standpipe," is attached above each connection.

In many of the larger cities, as New York, Cleveland, Boston, and Detroit, high-pressure or auxiliary pipe systems have been installed in which the water is under a pressure great enough to supply all fire streams when directly connected to hydrants or standpipes without requiring the use of fire engines. This high water pressure is generally obtained by means of fire boats or special auxiliary pumping stations in which the latest type of centrifugal pumps are installed.

Installation and Equipment

The number of standpipes which are installed in a building depends upon the area and shape of the building, the exterior exposures and the other means provided for extinguishing fire. In most instances, at least one standpipe is installed in each section of the building divided by fire walls. In small buildings the standpipes which supply the larger streams are sometimes used to also supply the smaller or first-aid streams, but in the larger buildings, separate standpipes are very often used for the larger streams and for the smaller ones. Where buildings are protected with an automatic sprinkler equipment, the first-aid streams are generally supplied from this system.

Standpipes are generally located in, or near, stairway shafts where they are accessible to the persons who use them. The size of the standpipes is dependent upon the height of the building and the size and number of fire streams which are likely to be operated simultaneously, the sizes varying from 2½ inches to 8 inches in diameter.

The equipment at each hose station constitutes the working end of the standpipe system and furnishes the means whereby the water is applied to the seat of the fire. Each standpipe is provided with a hose station on each floor, the outlet being placed about five feet from the floor so that the valve can be easily operated. The hose valves are generally of the straightway solid wedge type, made of bronze or some other non-corrosive material. The valves are placed below the fire hose and are pro-

vided with a drip connection just outside the gate so that any slight leakage past the valve seat is carried away and does not enter the hose.

Unlined linen fire hose is used for interior standpipe equipment because it is low in cost, light in weight, can be easily

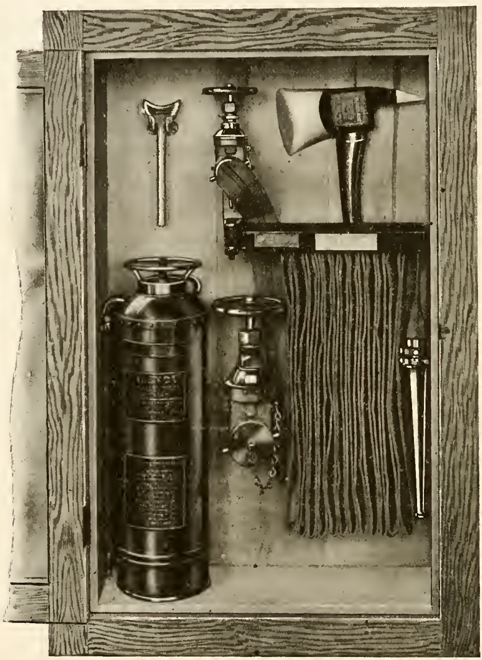

Fig. 2—Bowes "Labeled" Semi-Automatic Hose Rack for 1½ Hose. Mfd. By W. D. Allen Mfg. Co.

handled and stored in small compass, and is more durable in the dry heated atmosphere found in buildings than hose containing rubber. In cases where the atmosphere is damp, and at the roof hydrants, cotton rubber-lined fire hose is used. The hose stations provided for the city fire departments are equipped with

2½-inch hose, as this is the size generally used by the fire departments for inside work, the length being about 100 feet. Inasmuch as persons untrained in handling fire streams are in danger of being maimed or even killed if allowed to handle a 2½-inch fire stream, most of the more recent standpipe systems have separate hose stations equipped with a 1½-inch hose for use by the occupants of the building.

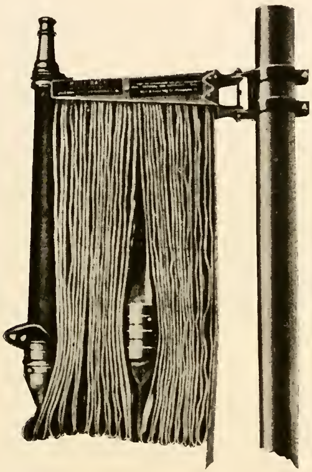

Fig. 3—Wirt and Knox Storage Hose Rack Showing Underwriters' Playpipe.

Fig. 4—Glazier Universal Standpipe Nozzle.

The hose racks or reels are generally of the swinging type and are so constructed that the hose can be very easily run out when required for use. They are clamped directly to the standpipe, when the latter is exposed; fastened to the wall; or clamped to a nipple attached to the hose valve. Fig. 2 illustrates a hose rack designed for 1½-inch hose which is semi-automatic in its action, in that the water can be turned on before the hose is pulled off and laid. The hose is supported on pins, and when the nozzle is grasped and run out the hose is released fold by

fold. Fig. 3 illustrates a rack designed for the storage of 2½-inch hose and has a special nozzle holder for supporting the Underwriters' playpipe, as shown in the illustration.

The playpipe for the 1½-inch hose are of brass about 8 or 10 inches in length and have a discharge orifice of about ½-inch. The Underwriters' playpipe which is used by most fire departments on 2½-inch hose is provided with swivel handles and has a discharge orifice of 1⅛ inches.

Roof hydrants and monitor nozzles are a very valuable part of a standpipe equipment, especially as a protection against exposure fires or conflagrations. Where the roof hydrants are not protected from frost they are controlled by a gate valve which is located under the roof, the gate valve being operated by a handwheel connected to a rod or valve stem which passes through the roof. Monitor nozzles are employed to furnish heavy streams where the exposures are severe and are valuable because of their commanding positions. They are usually exposed to freezing and, therefore, the water is controlled by a gate valve located under the roof, similar to those described for roof hydrants. Fig. 4 shows a form of nozzle which is "universal" in operation; that is, it may be turned in any direction, and, at the same time, swing in any arc of a circle.

Maintenance

After a standpipe system has been installed, it is very often looked upon as requiring no special care or attention. Probably this is one of the chief reasons for the loss of confidence on the part of some city fire departments in interior standpipe systems. The use of the building or the operation of the plant is not directly dependent on the maintenance of the standpipe system in operative condition, and in many cases such an equipment probably suffers more neglect than any other part of the equipment provided for the extinguishment of fire. Interior standpipe and hose systems should be systematically inspected and maintained in an operative condition.

The hose is the most perishable part of the whole equipment; but, if given proper care and attention, unlined linen hose will

last for many years. Linen hose should never be wet unless used in case of fire and then after it has been used it should be hung up and thoroughly dried before being put back on the rack. It is also advisable to remove the hose from the rack occasionally and rerack it with the folds at different places, so as to prevent permanent set or break at the folds.

Hose valves very often cause annoyance and expense unless carefully examined at intervals to see if they are in an operative condition and are tight. Being used so seldom they are liable to become encrusted with dirt or rust, making it almost impossible to open them without a wrench. Special attention should be paid to each valve to see whether or not any leakage past the gate is occurring, as leakage rots the hose and renders it unreliable.

Once a year, new gaskets should be installed in the hose couplings, both at the hose valves and at the nozzles.

Private Fire Department

It is obvious that a well-equipped standpipe system is of little value unless a squad of men are available who are trained to handle the same. Mr. R. H. Newburn, in a paper presented before the National Fire Protection Association on private fire departments, stated:

"The organization and training of the private fire brigade is one of the most important problems in the field of fire protection. Fire pumps and distribution systems, however perfect, will prove of small value if we neglect the means by which their possibilities are to be realized.

Frequently in laying out systems of fire protection, the organization of the fire brigade fails to receive the consideration which its importance deserves. It would seem but simple business economy that the means whereby the expenditure for costly installation of pumps, water mains, and hydrants are to be made effective, should be developed to its highest efficiency, for in any system of fire protection, working efficiency will depend largely on the skill with which it is handled.

Aside from its primary object, the private fire brigade has possibilities for the alert mill manager or factory superintendent

in promoting amicable relations between the management and employees, which, if properly developed, will amply repay any reasonable expenditure of time and energy given to its organization. The motive underlying a fire brigade organization is fundamentally one of mutual protection; to the manager, the safeguarding and preservation of his plant; to the employee, the permanency of work and wage. When this relationship is properly understood and the interest of each party made the common interest of both, we have then laid the broad foundation for a successful and efficient organization.

Membership in the brigade should of itself confer distinction and, if possible, carry with it the exercise of some minor privilege sufficiently attractive to make membership desirable and sought after. . . .

Standpipe Company.—For department stores, factories, large mercantile and office buildings, and various other risks equipped with interior standpipe systems, a separate company should be organized to operate the system and to handle the hose lines connected therewith.

The company should comprise not less than sixteen (16) men, or a sufficient number to concentrate four hose lines on any one floor, or, where less than four connections are available, there should be a sufficient number of men to man all the lines, as hereinafter provided.

The company should be in command of a captain, in direct charge, and for each hose stream there should be a valveman and two pipe men with duties as follows:

Valveman: To remain at hose gate to turn on and off the water and assist in unreeling hose.

Pipemen: To handle and have direction of playpipe and assist in unreeling and laying hose lines.

Hoseman: For each hose stream opened there should be one extra man available to assist, if necessary, in unreeling hose or in directing playpipe.

Where standpipe systems are supplied from gravity tanks or by means of connections with public mains, the organization should provide for a "main valveman," who shall be charged with the duty of seeing that the shut-off valve between source

of supply and standpipe system is open and in good working order.

For all factories and department stores, there should be certain members of the fire brigade designated to unreel hose connected with inside hydrants or standpipe systems, and to stretch same carefully on all floors.

Attached to each fire brigade organization there should be an experienced plumber, selected from those connected with the plant or store, preferably one familiar with the distribution system and with location and operation of all valves; also, where electric current is used, provision should be made for the attendance at all fires of a practical electrician, having first knowledge of all conductors, their voltage, and of the location and operation of all protective devices. These men are to report to the chief or assistant chief, and to be subject to their orders.

At plants where the fire service is supplied by fire pumps, it is advisable to have the engineer in charge and his assistants enrolled in the fire brigade membership, in order that they may be in close touch with the purpose and objects of the brigade. During fires, and except when prearranged for fire drills, the engineer and assistant should remain on duty at the pump."

WATER SOFTENING

BY W. M. BREADY, JR*

Engineering Department, the Kennicott Company.

The importance of water softening is being realized more and more every day. A few years ago water softening apparatus was considered a luxury, or a needless investment, but today it is one of the first installations thought of when expansion or building is being considered. It is very important, at times being the chief reason for the successful operation of a plant that had always given trouble. In most cases it is a big help and a wonderfully well paying financial investment.

It is no exaggeration to say that the failure to understand the costly disadvantages of hard water is costing American Industry millions of dollars a year.

When ground space is limited or a particular location desired near the centers of raw material and labor supply, a manufacturer is frequently forced to locate his plant where the water is polluted, hard, contaminated, roily or muddy. The result of these improper water conditions is invariably an unnecessarily high boiler room overhead expense, therefore high cost of power; waste of fuel, and where the water is used for manufacturing purposes, the product is greatly influenced by the improper water supply. In many cases the output of such a manufacturing plant is greatly reduced.

These are the chief reasons why all the modern power plants, textile mills, breweries, ice plants, distilleries, Steel plants, paper mills, laundries and hundreds of other industries, where the water supply is an important factor, are beginning to realize the value and the necessity of water softening apparatus in connection with other machines.

The power plants use water for boiler feed purposes; the textile mills use it for their manufacture as well as in their power plant; breweries use it for their product and also their boilers; ice plants use water in the manufacture of raw water ice and in the power end as well; distilleries use it chiefly in the boiler room; steel manufacturers use it for boiler feed; paper mills, the largest users of water, per dollar of business, use it in

*Class of 1915.

connection with the manufacture of paper as well as in the production of power, and laundries use water throughout their entire business. It might be stated here that this is one of the big fields for water softening work, not directly connected to engineering.

The urgent necessity of operative economy being felt in all of the above lines of industry is giving great prominence to the water softening industry. Wherever these plants exist, whether they are using water for steam or large quantities for commercial purposes, there the costly disadvantages of hard water are being realized and engineers are looking toward the installation of water softening apparatus as the one practical means to get economical and satisfactory operation.

What Hard Water Is.

All water as it starts to fall is soft, but in passing through the air it absorbs carbonic acid gas, or more accurately speaking it absorbs carbon dioxide and thus forms carbonic acid gas. When this slightly acid water soaks into the earth it causes various salts and minerals to be dissolved and absorbed into the water.

As a result of these chemical reactions we find practically in all natural waters, carbonates, sulphates and chlorides of lime, magnesium and sodium; also silica, oxide of iron and other minerals in varying degree and combination according to the character and location of the soil with which the water has come in contact.

Water is frequently contaminated with sewage and industrial wastes from which it absorbs sulphuric acid, hydro-chloric acid, acetic acid, tannic and other acids that appear as a wasted by-product of manufacturing industries.

These chemical compounds, which are absorbed by the water, all dissolve just as common salt dissolves when added to water, leaving no visible trace of their presence to the naked eye. Water may be unusually clear and still be very hard.

A sharp distinction should be made in regards to matter in solution, and matter in suspension, when the water question is considered. The matter in suspension consists of mud, sand or foreign particles which do not dissolve in the water but are

easily detected by the eye. These can readily be removed by simple filtration, not necessarily requiring softening.

The fact that water is clear is no criterion as to the softness of the water, as stated before. Results show that out of 100 samples from all parts of the country, taken so that they fairly represent general conditions, an average of 1.96 grains of suspended matter per gallon was found, whereas the troublesome

solids in solution averaged 34.22 grains per gallon or 4.88 pounds of scale per 1,000 gallons.

Effects of Hard Water.

When water containing these salts of calcium, magnesium and iron are used in boilers the evaporation leaves the salts in various forms on any surface with which they come in contact with.

In boiler feed water it is these various salts that are directly responsible for scale and indirectly responsible for leaky flues, mud burning and many other troubles incidental to steam power plant operation.

The steam which leaves the boiler, carries none of these salts with it. The result is a concentrated solution containing scale forming elements which at the high heat due to boiler pressure will be precipitated and deposited on the flues and shell of the boiler in the form of scale. Very hard waters will give a large quantity of scale, while the ones less in hardness will deposit smaller amounts. The character of the scale will depend entirely on the salts in solution.

It is a proven fact that a scaled boiler is an expensive one, and the fact that the scale is only a thin scale, does not displace this statement. The scale tends to shorten the life of the boiler and places an insulator of heat on the inside of the boiler, thus wasting fuel and cutting down the steaming capacity and efficiency of the boiler.

The following table, taken from Prof. Gebhardt's "Power Plant Engineering," will show the effect of different kinds of scale:

Thickness of Scale	Character of Scale	Percentage of Heat Loss
.02	Hard dense	9.1
.02	Hard	2.02
.033	Soft	4.3
.033	Very hard	3.5
.038	Medium	4.03
.04	Soft porous	6.82
.04	Hard dense	3.07
.042	Very soft	4.54
.047	Hard	2.75
.065	Medium	2.39
.07	Sot	2.38
.07	Hard	4.43
.085	Soft porous	19.00
.089	Very soft	4.95
.11	Hard porous	16.73
.13	Hard dense	6.75

From this table it can easily be seen that no definite rule can be established as regards the heat loss due to certain thicknesses of scale In some cases the soft scale is worse than harder scales of the same thickness.

These scales are comparatively thin as compared with some that have been taken from power plants that I have had to deal with. In several cases I have seen two inch flues incrusted so that it was hard to force a lead pencil into the center. Samples have been received varying from one-quarter of an inch to one and one-quarter inches, the latter having been removed from a locomotive.

A few other troubles that can be charged to hard water supply are the increase in boiler repair and frequently causing inopportune or costly delays or "shutdowns" in the plant.

The most important of all is the scale, as mentioned before. With it goes the cost of repair, excessive cleaning, including tools, power and labor necessary for such work.

Where water is used directly in the manufacture, as in ice plants, breweries, textile mills, paper mills and launderies, defectiveness and inferiority of the product can be directly attributed to the effect of hard water. This makes competition harder and sometimes results in the loss of trade due to poor quality of goods. Some of these reasons may appear to be sales arguments. yet they describe conditions as they are existing in a great number of places which could be enumerated without very much trouble.

In ice plants hard water is largely responsible for the dense core in the ice. Soft water will not completely eliminate this, but the improvement due to its use will be very noticeable.

In the laundry industry the importance of soft water is very great. One grain of hardness per one thousand gallons will destroy 1.7 pounds of soap before a suitable lather for washing is obtained. The use of soft water will greatly reduce the soap expense and give better results.

In the textile mills the most favorable results in dyeing and finishing are obtained in clear, soft water.

In breweries a purified and treated water is used for brew. The most desirable water is one hard with sulphate of lime and

free from calcium or magnesium carbonates. A water softening equipment will handle this situation very easily.

In distilleries the fermentation takes place quicker in soft water and the retorts and condensers are always working at their highest efficiency.

These are some of the industries where the water is used in the manufacture as well as for power. The water end of each industry could thus be analyzed and the advantages and necessity of soft water shown. but it would be a waste of time.

What Soft Water Is.

Water that has been rid of its Calcium, Magnesium and Iron salts entirely, or lowered to such a degree that the salts remaining in solution are injurious to manufacture or boiler feed is called soft water. Some authorities state that water of a hardness of seven grains or less per gallon is considered soft water, but in actual practice the water is reduced to a hardness of four grains or less. In some machines of a newer design the hardness of the water is reduced to zero.

The term hardness which is used in regards to water analysis is a standard term of comparison. It is the amount of standard soap solution, in cubic centimeters, that is destroyed by the salts in solution in 100 cubic centimeters of water. The common test is to run the required amount of soap solution into the measured amount of water until a permanent lather is formed.

(Concluded in next issue)

VINEGARS

BY JOHN J. SCHOMMER*

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Vinegar is a composition of acetic acid and water. Besides these, depending on the substances fermented, yeast present and the temperature, varying quantities of bouquet ethers, succinic acid, glycerine, ash, solids, and sugars are also present.

The vinegars on the market today are known as follows:

Spirit, or distilled vinegar,
Molasses vinegar,
Cider vinegar,
Grape vinegars,
Malt vinegars.

Spirit vinegar is used principally for pickling meats. Molasses vinegar is a sugar vinegar and is used for pickling when distilled, and, when not, it is sold for table uses. Cider, Wine, and Malt vinegars are chiefly used for salads and cooking purposes.

Vinegar is made by placing a liquid such as fruit juices weak in alcohol strength in an open cask. This cask is open at the top for free excess of air and to it is added "mother of vinegar" (a gelatinous scum impregnated with vinegar ferments that aid in the oxidation of the alcohol to vinegar). As the vinegar forms by the oxidation of alcohol from the oxygen of the air, it is drawn out at the bottom and fresh juice added on top. The casks are filled about 2/3 full. These casks can be used continuously for years until the sediment of yeasts, argols, and impurities make it necessary for a thorough cleaning. The process is known as the "Orlean's Process." Vinegar by this method is slow work as months are required for the finished product. This "slow process" is rarely used by the manufacturers of vinegar for the market. The generator process is now used almost entirely for the manufacture of vinegar on a commercial scale. In this process a cask is used about 8 feet high and 3 to 5 feet in diameter. About a foot above the bottom of the cask is a false bottom with a great many small holes in it. On this perforated bottom are packed small coils of beechwood shavings nearly to

*Class of 1912.

the top. Near the top is a dumping apparatus. Into this the liquid flows until the weight is sufficient to dump it. Just below the false bottom holes are bored through the cask for the entrance of air. A faucet is attached to the bottom chamber to withdraw the liquid. These casks are placed in series one above the other. Three such casks form a battery. The alcohol in passing through one or two is not entirely oxidized to acetic acid.

The generators before using are put in a working condition by pregnating them with stale beer or substances of a nitrogenous and phosphoric nature. This is food for the vinegar ferments. The alcohol liquor is mixed with strong vinegar warmed and sent through the generators. The fermentation causes heat, which in turn causes a draft. The air is sucked through the holes just below the false bottom and up through ranges from 20 to 35°C. If temperature is low generators get cold and feed too slow necessitating the liquid to be rerun through the battery. If too fast, the generator "burns out"; that is the ferment is killed and oxidation doesn't take place. The generator is then cleaned out and replenished with new coils of beechwood.

The essential conditions necessary for generated vinegar are:

1. Abundant excess of air.
2. Temperature of 20 to 35°C.
3. Presence of food for the vinegar ferments.
4. Presence of vinegar ferments
5. The liquid to be generated should be about 25 proof in alcohol (12½%.)
6. Generator so regulated that the alcoholic liquor drips in no faster than acetic acid runs out.

Spirit or distilled vinegar is made by fermenting a mash pitched with a suitable yeast, and then controlled, so as to produce a maximum yield of alcohol. The mash consists of 85% corn, 10½ rye and 5% malt (sprouted barley dried). To every bushel of grain, 45 gallons of water are added. The corn is cooked and coarse rye meal stirred with the corn. This mixture is well boiled. Malt is next added to hydrolize the starch to sugar and the mash is slowly cooled down. Water is added and after a time the mash is cooled to 100°C and a strong distillery race of

yeast is planted. After the sugars are fermented, the mash is sent to the distill. Alcoholic liquid not over 25 proof (Government requirement) is then sent to the generators while the dried grain of the mash is sold for cattle food.

Spirit vinegar is a colorless product containing practically no ash or solids. Its principle use is for pickling purposes—meats and pickles.

Molasses or 'black strap" vinegar, often called sugar vinegar, is made from the molasses refuse of the sugar refineries. The molasses is diluted with water, cooked, cooled, and fermented with brewery yeast in large vats. If the finished product is to be sold as sugar vinegar it is clarified with bone dust and generated. If it is to be sold as spirit vinegar, it is, after fermentation, distilled and then generated.

This vinegar, unless distilled, has the color of cider vinegar and is very often sold as a substitute for it.

Cider vinegar is made from apples such as windfalls, specked, gnarled, or otherwise unfit for table use. The apples are shredded, and made up into big cheeses, subjected to hydraulic pressure, and the juice is run into tanks and permitted to ferment either by the addition of yeast or by the wild yeasts always present on the fruit. This juice after fermentation is then generated.

Skins and cores from apple canning factories also furnish some of the material from which cider vinegar is made.

Cider vinegar is light yellow in color when first made, but on ageing, takes on a dark amber color. It has solids and considerable ash. Depending on the temperature of fermentation and the race of yeast, bouquet ethers are formed and impart the aroma, which any good cider vinegar must have. Cider vinegar is used principally for salads and cooking purposes.

Grape or wine vinegar is made from juice expressed from grapes, fermented, and generated. Grapes, however, are generally too high priced for vinegar purposes, therefore, a large share of the wine vinegar is made from spoiled wine. The spoilage generally consists of acetic ferment which impairs its flavor for drinking purposes.

The spoiled wine is run over the generators. Wine vinegar is high in solids and has considerable ash.

Malt vinegar is made from a mash. This mash differs from the distillery mash used for spirit vinegar. The malt mash is similar to a beer mash with the exception that an effort is made to produce an extract as rich as possible in a sugar, maltose, but poor in dixtrine. Malt is rarely used alone but as the basis. Barley, oats, sugar or syrup are often used with the malt.

This mash is fermented, generated, and aged. This vinegar contains considerable quantities of nitrogenous matter and it runs high in phosphates, dixtrine and maltose.

The followng table shows the difference between the market vinegars as regard the principal ingredients that are analyzed to form an opinion of the purity of the product:

	Spirit	Molasses	Cider	Grape	Malt
Solids	0.14%	6.62%	2.10%	1.30%	2.6%
Ash	0.06%	0.06%	0.31%	0.19%	.25%
Alkalynity	14	100	34	14	8
Total Phosphorous	None	None	30 mg.	.042%	1 to 6%
Insoluble Phosphorous	None	None	13 mg.		
Soluble Phosphorous	None	None	17 mg.		9 mg. up.
Acetic acid	5 to 10%	4.5%	4.5 to 6%	5 to 10%	4.5 to 6%
Sugar	Trace	0.64%	.50%		
Sugar in solids			23.8%T.S.		
Non-sugar solids			1.6%		
Ratio—Ash to non-sugar solids			1:5.1		
Glycerine			0.24%	0.141%	
Optical rotation	None	Dextro-rotary before, and Laevo rotary after inversion.	0.1° to 4° Ventske 200 m.m. tube	Slightly Laveo rotary.	-0.56° to positive reading. Ventske 200 m.m. tube.

Vinegar or acetic acid is formed by the oxidation of alcohol thus:

$C_2H_2OH + O$ (from air)—C_2H_4O (Acetaldehyde)

$C_3H_4O + O$ (from air)—$C_2H_4O_2$ (Acetic acid).

Vinegar bacteria play an important part in the transformation. Just as sugar is fermented by an enzyme of yeast, vinegar is made by the aid of an enzyme of the vinegar bacteria.

In 1906 Bucher and Gaunt succeeded in showing that these enzymes really existed. Mother of vinegar was freed of water by centrifugal force and the residue remaining was treated with acetone. This treated residue oxidized alcohol. Toluene was added to kill any living organisms and the mixture was ground to a paste with chalk and dried 3 days in a current of air at 28°C.

This mixture oxidized alcohol and produced acetic acid from 0.5 to 2 per cent strength. The maximum yield was 4 per cent. From this experiment there can be no reason to doubt that acetic bacteria owe their oxidizing powers to one or more enzymes present.

* * * * *

The Chicago Chapter of the American Association of Engineers at its meeting on September 1st had the pleasure of hearing Alderman Chas. E. Merriam speak upon City Government in Chicago. Mr. Merriam spoke particularly upon engineering subjects which came to his attention on the council committees, and highly commended the Association for its activities in civic work. He said, "for the engineer not to take part in political affairs is high treason. The engineer is the proper citizen to give the city and the people facts regarding public affairs because he deals with facts. We want your co-operation in engineering matters." He further stated "the department of Public Service is made up largely of engineering positions and that it has had some good men and still has some good men but it is only operated at about 15% or 20% efficiency."

A TELEPHONE CALL

BY JAMES W. COHN*

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(Note—Part II will appear in the next issue.)

PART I.

The telephone system as a whole seems to be very complicated and to the layman a telephone exchange leaves an impression of a mass of neatly arranged wires connected to things of mystery. The purpose of this article is to give its readers a conception of the functions of these things of mystery and the part they take in giving telephone service.

The telephone exchange is a terminal at which calls from the district in which that exchange is located may be routed to the exchange in the district that the called party is located; and is a point at which calls are received from other exchanges to be transmitted to the subscribers in its district. Hence an exchange has two distinct functions; first, to receive calls from subscribers in its district and transmit them through exchanges in other districts to the called subscriber; and second, to receive calls from other exchanges and transmit them to subscribers in its own district. The place in the exchange where the call is received from subscribers in its own district is called the "A" board, but the place where calls are received from other exchanges to be transmitted to its subscribers is called the "B" board. In small exchanges the "A" and "B" boards are combined in one, but in all Chicago exchanges they consist of two

*Class of 1917

separate boards operated by different groups of operators. In the common battery system, which is in general use in Chicago, the telephone exchange also serves as a central point for distribution of energy required to operate the telephone system.

We shall first discuss, in a general way, what operations are performed when a subscriber in one district, which we will call the "calling subscriber," calls another subscriber in another district, who is known as the "called subscriber"; and then discuss the circuits brought into operation when a subscriber on a four-party nickel circuit in one district calls a subscriber on a four-party nickel circuit in another district, which will take into consideration several of the most modern circuits now in general use in the Chicago telephone system.

Let us assume that Kedzie 1 wants to call Haymarket 1. Kedzie 1 will take the receiver off the hook; a small lamp on the "A" board of Kedzie exchange will light. This lamp is situated directly over the answering jack which is a terminal of Kedzie 1. The operator inserts one of a pair of plugs which are the terminals of the cord circuit; operates a key which connects the operator's telephone set to the pair of cords being used, and says "Number please." The subscriber answers by saying "Haymarket 1"; the operator restores the listening key to its normal position and pushes down a button marked "Ked." which connects her telephone set to that of a "B" board operator at Haymarket exchange; the "A" board operator repeats the number to be transmitted saying, "Kedzie 1"; the "B" board operator assigns a trunk which terminates in a jack on the "A" board in Kedzie exchange and a plug on the "B" board in Haymarket exchange; the "A" board operator tests the trunk assigned by touching the tip of the mate of the answering cord, known as the connecting cord to the sleeve of the trunk assigned; and if found not busy, inserts the plug in the jack of the trunk, which lights a lamp on the "B" board; the "B" board operator tests the jack marked "1," which is a terminal of Haymarket 1, by touching the sleeve of the jack with the tip of the plug; and then inserts the plug in the jack which extinguishes the trunk lamp. The polarity of the ringing current is selected and the subscriber's telephone is rung automatically. When the called subscriber an-

swers, the ringing stops automatically and the two parties can carry on a conversation.

On the "A" board, corresponding to each pair of cords, there are three lamps, two of which are known as supervisory lamps and the third is known as the nickel detector lamp. The supervisory lamps are extinguished when both parties are talking and are lit when they put their receivers on the hook. The nickel detector lamp, after the connecting cord is inserted, remains lit

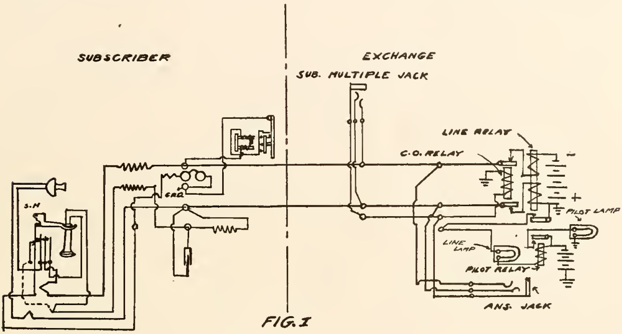

FIG. I
SUBSCRIBER LINE AND TELEPHONE CIRCUIT

until the nickel is put into the slot. After the parties have completed their conversation and replaced their receivers, the supervisory lamps light and the operator operates a key known as the nickel key, corresponding to the pair of cords being used, thus cashing the nickel. The "A" operator then takes the plugs out of the jacks which light the lamp on the "B" board. The "B" operator then takes the trunk plug out of the jack marked Haymarket 1 and the call is completed.

The above operations are performed by means of electrical circuits consisting of resistances, condensers, repeating coils, induction coils and relays.

The subscriber's set, the part of the telephone system with which the public comes in closest contact, consists of a transmitter, a receiver, an induction coil, a switch-hook with contacts, a condenser, a means of being signaled, and a means of collecting and depositing the nickel. The transmitter is a device by

means of which sound waves are changed to electrical waves. The receiver is a device by which the electrical waves are changed into sound waves. The other apparatus is used for transmitting these waves to the receivers of other subscribers, for signalling purposes and collecting the fees. Referring to Fig. 1, we notice that when the calling subscriber takes his receiver off the hook three of the springs at the switch-hook (S. H.) come in contact, so that current flows from the negative side of the office storage battery, through a 1,000 ohm winding of the line relay, through a back contact of the cut-off relay, over the line, through a contact of the switch-hook, through a winding of the induction coil, through the transmitter, over the other side of the line, through another back contact of the cut-off relay, through a 1,000 ohm winding of the line relay, to the positive or grounded side of the office battery; thus completing the circuit. The current through the line relay will operate it, completing the line lamp circuit, so that current will flow through the winding of the pilot relay through the line lamp to ground; thus lighting the line lamp and completing the pilot lamp circuit and lighting it. The pilot lamp, one of which is located in each panel of the board, indicates to the "A" operator that one of the subscribers terminating in that panel is calling. The line lamp indicates the subscriber. The "A" operator at Kedzie exchange then inserts the plug of the answering cord of the cord circuit into the jack immediately below the line lamp that is lit.

Referring to Fig. 2 (the "A" board cord circuit), when the plug of the answering cord is inserted in the answering jack, current flows through the answering supervisory lamp, through the 83 ohm winding of the resistance coil, through a contact of the 122 special relay, to the sleeve of the answering jack, through the winding of the cut-off relay (Fig. 1) to ground. This will operate the cut-off relay, cutting off the current from the line and opening the circuit of the line relay, allowing it to fall back to its normal position, thus opening the line lamp circuit, which in turn will open the pilot relay circuit and the pilot lamp circuit, thus extinguishing the line and pilot lamps. The answering supervisory lamp (Fig. 2) does not light due to the fact that current flows from the negative side of the office bat-

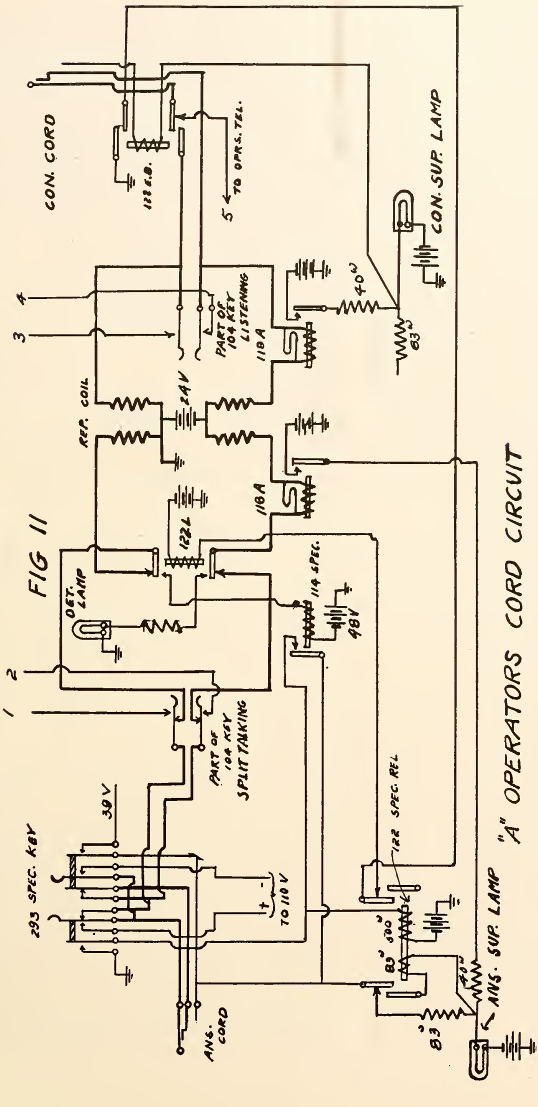

FIG 11

"A" OPERATORS CORD CIRCUIT

tery through one winding of the repeating coil, through a contact of the 122 L relay, through a contact of the 104 key, through a contact of the 293 key, to the ring of the plug, over the line, through the short at the subscriber's instrument, back over the tip side of the line to the tip of the cord, through a contact of the 293 key, through a contact of the 104 key, through a back contact of the 122 L relay, through the 118 A relay, through a winding of the repeating coil to ground. This will operate the 118 A

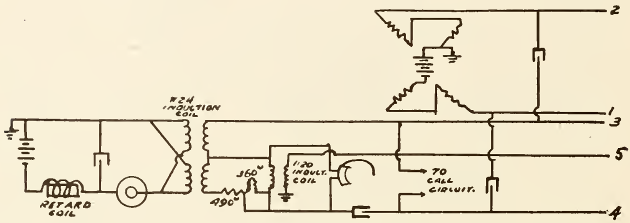

FIG III
"A" OPERATORS TELEPHONE CIRCUIT

supervisory relay connecting the battery through the contact of the 118 A relay and the 40 ohm resistance to the lamp. Hence we have batteries connected to both sides of the lamp. The voltage acting on the lamp is equal to the difference in drop across the 120 ohm lamp and the 40 ohm resistance coil, which has the same effect as connecting the 40 ohm resistance coil in shunt with the lamp. Hence there will be a small amount of current through the lamp, but not enough to cause its filament to give off an appreciable amount of light.

The "A" operator pushes a button down marked "Ked.," the Kedzie order wire, which connects her telephone set, as indicated in Fig. III, with a "B" board operator's telephone set at Haymarket exchange. The "B" operator assigns a trunk and after the "A" operator tests it, she inserts the plug of the connecting cord. Current will flow from the negative side of the battery (Fig. II), through the connecting supervisory lamp, through the winding of the 122 E. B. relay, to the sleeve of the plug, to the sleeve of the trunk jack, which is grounded. The connecting supervisory lamp lights and the 122 E. B. relay operates, disconnecting one of its contacts from the operator's telephone circuit

and making contact with the grounded side of the line. Another set of contacts is operated allowing current to flow through the winding of the 122 L relay through a contact of the 122 special relay to ground on the contact of the 122 E. B. relay, which operates the 122 L relay cutting off the calling party from the trunk and allowing current to flow through the winding of the 118 A, through the contact of the 122 L, through a resistance, through the detector lamp to ground, which lights the detector lamp; thus indicating to the operator that the nickel has not been deposited. The operator says, "I do not get the signal for your nickel." The subscriber reminded of the fact deposits a nickel, the weight of which causes two contacts in the nickel box to make, grounding the battery or negative side of the line; thus allowing a 48 volt battery current to flow through the winding of the 114 special relay, through the closed contact of the 122 L relay, through a contact of the 104 key, through a contact of the 293 key, to the tip of the cord, over the line to the ground, caused by the nickel. This will operate the 114 special relay allowing current to flow through the 500 ohm winding of the 122 special relay, through the contact of the 114 special relay, to the sleeve of the answering cord, to the ground on the sleeve of the answering jack, which will operate the 122 special relay, which opens the circuit through the winding of the 122 L, allowing it to become normal; thus extinguishing the detector lamp and connecting the calling party to the other part of the circuit. The 122 special relay remains operative or "locks-up" due to the current through the 80 ohm winding of the 122 special relay through its contacts to the ground on the sleeve of the answering jack. When the parties have completed their conversation and hung up their receivers, both supervisory lamps are lit and the operator operates the 293 key which opens all its contacts and makes contact between the long spring on the right hand side of the key, as drawn in Fig. III, and the spring to its right, which allows negative 110 volt direct current to flow through the closed contacts of the 293 key, to the tip of the plug, over the line, through the windings of the polarized magnet in the nickel box to ground, which will operate a pivoted armature and allow the nickel to

roll down a slot to the coin box. If it is necessary for the operator to return the nickel she operates the 293 key in the opposite direction which opens all contacts of the 293 key and makes contact between the long spring on the left hand side of the 293 key and the spring to its left, allowing the 110 volts positive direct current to flow over the line through the winding of the polarized coil to ground, operating the pivoted armature in a direction opposite to that direction when the nickel was cashed, allowing the nickel to slide down the return slot. In either case, for cashing or returning, the 110 volt current flows through a relay (not shown on the figure) which closes a lamp circuit, known as the nickel pilot circuit, which notifies the operator that the nickel has been cashed or returned.

The cord circuit performs the following operation: It completes the connection between the calling subscriber and the trunk; it acts as a means of connecting the operator's circuit to the called or calling subscriber; it furnishes talking current to the subscriber and signaling current to the "B" board trunk circuit; it puts current on the sleeves of the jacks, which affords a busy test for operators in other positions; it automatically cuts off the line signaling apparatus; and it furnishes means whereby the operator can control the coin box.

The "A" operator's telephone circuit is connected to the cord circuit by means of the 104 key and a back-contact of the 122 E. B. relay (Fig. II). Points 1, 2, 3, 4 and 5 of Fig. II are connected to points 1, 2, 3, 4 and 5 of Fig. III respectively. The transmitter current is supplied to the primary circuit (Fig. III) by the storage battery through a retard coil in order to keep the noise of the battery off the circuit and to prevent cross talk. The condenser is connected across the primary circuit to afford a path for the fluctuating talking current so that it need not be distorted by passing through the retard coil. The secondary circuit is connected to the 104 key, through points 3 and 4 which, when the key is operated, is connected to the subscriber's telephone circuit. The receiving circuit is connected from one side of the line, through the receiver, through one-half of the secondary winding, through a 490 ohm resistance to the same side of the line. If we consider the two halves of the secondary winding

as separate and equal sources of current, we have a three-wire system with the receiver on the neutral wire, the subscriber's line and instrument on one side, and the 490 ohm resistance on the other side. When the system is balanced we have no current through the receiver due to the talking current induced from the primary circuit to the secondary which makes the operator's circuit anti-sidetone; that is, the operator may talk to the subscriber without hearing herself talk and the noises in the room and due to her breathing will not interfere with her hearing the subscriber. The condenser in the secondary circuit is connected in series with the receiver to prevent the office battery from demagnetizing it and giving the operator a "bang" in the ear.

You will remember that when the connecting cord is inserted in the trunk jack and the called subscriber has not deposited the nickel, the battery and ground side of the line are disconnected from the subscriber. In order for the operator to converse with the subscriber, she operates the 104 key in the opposite direction to that when answering the call which connects points 1 and 2 (Fig. II) to points 1 and 2 (Fig. III), thus supplying talking current to the subscriber through the repeating coil and connecting her telephone set to that of the subscriber.

When a trunk or subscriber's line is busy there must be a plug of a cord in a corresponding jack in some other section, and since the tip, ring and sleeve of the jack in one section is connected in parallel or multiple with the tip, ring and sleeve of the corresponding jacks in every other section, the current on the sleeve of the plug flows to the sleeve of the jack, raising the potential of the sleeves of all the jacks connected to it. Hence, when the operator in another position tests a trunk by touching the tip of the connecting plug to the sleeve of the jack, current flows through the tip of the cord (Fig. II) through a contact of the 122 E. B. relay to point 5 (Fig. III), through a winding of the No. 20 induction coil to ground, which induces an E. M. F. in the other winding of the No. 20 induction coil, causing a current to flow through the operator's receiver, which will cause a click, thus notifying the operator that the trunk is busy.

The connecting links between the "A" board at each office and the "B" board of every other office and between the "A" and

"B" boards of the same office, consist of an order wire or call circuit and a number of trunks. The call circuit terminates in a key on the "A" board, the top of the plunger of which has the abbreviation of the name of the exchange at which the "B" board is located where the call circuit terminates. Each position on the "A" board is equipped with call circuit keys leading to the "B" boards of every exchange, and these keys are connected in multiple. On the "B" board, these circuits are connected to the "B" operator's telephone circuit. The number of circuits connected to each "B" board position depends upon the maximum traffic or calls between the respective offices.

The trunks between offices terminate on multiple jacks on the "A" board and plugs on the "B" board. The "B" board trunks are located in the same position on the "B" board to which the call circuit is connected.

The symbols for battery, placed in various places on the schematic wiring diagrams, are placed there for convenience in drawing. In reality the battery supply is taken from one large storage battery which is connected through fuses to copper bars on fuse panels. The battery supply for various circuits is obtained by connecting them to these bars, through suitable fuses.

We have now traced the call from its origin through its line circuit, to the "A" board, and through the cord circuit, to the connecting link. Part II will trace the call to its destination.

(Note.—The writer claims no originality as to the design or operation of any circuits discussed in this artcle.)

James W. Cohn.

HEATING AND VENTILATION OF THEATER AUDITORIUMS

BY WILLIAM T. BRAUN*

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Ventilation as applied to a room or building consists in supplying pure air to dilute and drive out that which has become vitiated. Perfect ventilation consists in supplying an adequate amount of fresh air, warmed or cooled to a comfortable temperature, in such a manner that the circulation shall be constant and thorough in all parts of the room or building, and at the same time without the creation of draughts.

Our respiratory apparatus was developed for a life in the open air, but modern civilization has just reversed this condition. The small fraction of the day which we spend in the open has been the cause of certain foul air diseases which exact a large mortality toll yearly. As a return to the natural outdoor life is impossible, unnatural or artificial means must be put in practice to correct the bad results of this confined existence.

The use of unsatisfactory, or the lack of proper care of, ventilating apparatus has been largely the cause of the so-called fresh air crank. While this fad may do much toward the better ventilation of our homes, it is evident that in places of amusement where several hundred or more congregate, and where at times a temperature of 50 degrees above the outside is maintained, it is absolutely impossible to depend upon natural ventilation.

Therefore ventilation especially applying to theaters is not a luxury—it is a necessity.

Dr. E. V. Hill of the Chicago Department of Health has made an exhaustive study of ventilation and he formulates eight requirements necessary for good ventilation practice. They are: an adequate air supply, comfortable temperature, proper humidity, perceptible air movement, freedom from drafts, freedom from dust and other imprities, minimum number of bacteria, and freedom from odors.

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*Class of 1913. Article reprinted by permission Exhibitors' Herald.

Ventilation Requirements

To arrive at the adequate air supply we must consider the composition of the air we breathe and also the ventilation. At a temperature of 70 degrees and 70% humidity the air inhaled is composed of about 1/5 oxygen and 4/5 nitrogen, together with about 1 7/10 per cent moisture and 4/100 of 1 per cent carbonic acid. In the process of respiration the lungs and the skin of the average person will change the air composition as follows: About 1/5 of the oxygen will be lost by the formation of carbonic acid, which will have increased about one hundred fold, forming 4 per cent of the whole, while the water vapor will also increase to about 5 per cent of the total volume.

The average adult makes sixteen respirations per minute of 30 cubic inches each, or about ¼ cubic foot per minute. If this exhaled air contains 4 per cent carbonic acid, then the average person will exhale 10 times ¼ times 4 per cent or 6/10 cubic foot of carbonic acid per hour. This is constantly being diffused throughout the air of the room, thus rendering it unfit for use.

If this carbonic acid gas could be disassociated from the rest of the air and expelled from the room without taking large quantities of otherwise pure air with it, the problems of the ventilating engineer would be simplified, but this cannot be done. Because of this rapid diffusion it is necessary to flood the room with fresh air in order that the purity be maintained at a safe value. The ideal condition would be to have this purity standard the same as that of the outside air, but the mechanical difficulties around such a system would be so great as to render it prohibitive. As before mentioned, good country air contains about 4/100 per cent carbonic acid or about 4 parts in 10,000. A standard of purity of 8 parts in 10,000 is considered fairly satisfactory in theaters.

The difference between these would be 4 parts in 10,000 or .0004. Consequently the amount of air needed per hour would be the cubic feet of carbonic acid exhaled per hour or 6/10 cubic foot divided by .0004 or 1,500 cubic feet per hour. A little higher standard of purity will raise the air required to 1,800 cubic feet per hour, which is about the maximum.

The manner in which the air is supplied to the occupants is of more importance than the amount, as air that short circuits through the room without mingling with the air in the room is manifestly of little value for ventilation purposes. Five hundred cubic feet per hour well distributed is of more value than 4,000 cubic feet which goes through the room without coming down to the breathing zone.

Our next requirement is comfortable temperature. Where the occupants are at rest as in a theater a temperature of from 68 to 70 is correct.

Our next requirement, the humidity maintained, has a direct bearing on the temperature necessary for comfort. Humidity is the water vapor or moisture mixed with the air in the atmosphere. The term humidity usually signifies relative humidity. Relative humidity is the ratio of the water vapor in a given space to the weight which the same space will hold when fully saturated at the same temperature. It is expressed as a percentage. The degree of moisture in the air has a nimportant influence on ventilation. When the air is saturated with moisture water is deposited on all bodies which conduct heat readily and which have a lower temperature than the air.

On the other hand, if the air is entirely deprived of water vapor it evaporates moisture from the body and thus causes an unpleasant sensation. When the air is very dry very rapid evaporation will take place from the body and when it is saturated no vaporation can take place. Consequently a mean condition between these two extremes is necessary for comfort. At a temperature of 70 degrees a humidity of from 40 to 50 per cent is most pleasant. Excessive moisture or dryness are more noticeable with higher temperature.

The next requirement, viz., perceptible air movement, is very important. To insure individual comfort and maintain normal heat distribution, especially with a high humidity, it is necessary that the air surrounding the body be removed. This can be accomplished best by currents of air in the room which are just perceptible to the occupants. A current of two feet per second with a temperature at 68 degrees and relative humidity of 40 per cent is about correct.

Air movement exceeding two feet per second is liable to be uncomfortable to patrons while seated in a theater, especially if the draft strikes them from behind. For a few minutes a greater velocity would probably be refreshing, but for a great length of time it is liable to produce serious consequences.

Our next requirement, freedom from dust and other impurities, has not received the attention it should have had in the past. It is becoming more recognized that dust contamination is just as important as freedom from the products of respiratory contamination. The popular conception that all outdoor air is fresh and pure is erroneous. It is rare to find any air containing less than 100 particles of dust per cubic centimeter even above the ocean, and in cities the numbers increase to almost one million particles per cubic centimeter during dry weather. Dust, when present in excessive amounts, irritates the mucous membrane of the lungs and respiratory passages and renders them more susceptible to the germs of disease.

A high dust count also means a high bacterial count. While the greater portion of these bacteria are not disease carriers, it is becoming more evident that their inhalation is not compatible with the best air conditions from the standpoint of health.

Our last requirement, freedom from odors, is one which no doubt many managers have tried to combat. Various perfumes will not remedy, but will merely help to neutralize the odor. If too strong they may even be obnoxious. The source of the odor should be found and removed.

Roof Ventilators

In discussing methods of ventilation a study of the circulation of air is first necessary. The effect of heat on air is to increase its volume and lessen its density. The heated or lighter air, because of its less density, tends to rise and is replaced by the colder air below. This available force for moving the air, obtained by heating it, is very feeble and is very likely to be overcome by the wind or othes external causes.

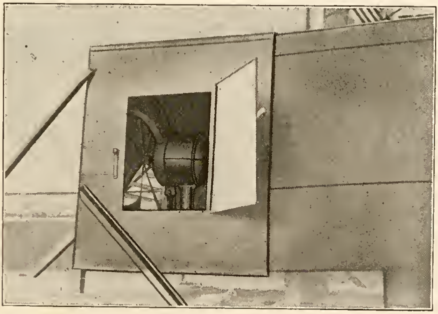
The above shows very clearly the close connection between heating and ventilating, and in solving the heating problem the ventilating should also be taken into account.

As the tendency of heated and vitiated air is to rise, the simplest method of ventilation for theaters is to draw this foul air out by means of the old style globe ventilators.

With the above system of ventilation, heating is usually accomplished by standard radiators of other types of direct radiation. The radiators being placed at or near the floor line cause the air to be heated. This heated air then rises and is exhausted through the ventilators. This method produces a suction and fresh air is drawn through the doors or other openings to replace the heated air. In winter a considerable draft may be caused by this system and those patrons seated near the door will be uncomfortable. Also strong winds are liable to reverse this system and a downward draft forced into the theater instead of exhausting the heated air.

There is a type of ventilator on the market known as the siphon type. The four siphons or vacuo chambers are so scientifically placed as to concentrate all passing wind currents into a steady, silent pulling force and by means of deflections placed opposite each siphon the wind is harnessed into a continuous powerful vacuum drawing out foul air at a tremendous speed. Under no condition does a particle of the outside wind enter the ventilator, as every opening is an outlet. With this type it is possible to estimate accurately the amount of air exhausted per hour, which is impossible with the globe type.

There is also a type having a square head with the air outlet points directly into the face of the wind. This also insures a more positive delivery.



A sure method of exhausting air through roof ventilators is by means of the penthouse arrangement with a propeller fan and shutter, as illustrated. In placing the penthouse on the roof the fan opening should be faced in the direction of the least prevailing winds. The slats of the shutter overlap each other when hanging down and prevent the influx of sweeping winds, draughts, snow or rain. This system will create a positive suction at all times as long as the fan is in operation and also insure an exhaust of any desired quantity of air. This system also insures ventilation in summer as well as winter.

To assist roof ventilators when no other system of ventilation is provided, exhaust or propeller fans are sometimes placed on either side of the screen near the ceiling. Occasionally it is necessary to run a duct from the auditorium over the stage to the outside air. In such cases the duct should always be of the same diameter or cross-section as the fan. This is also true of fans on roof ventilators.

The use of wall fans is not to be recommended. They simply stir up the air and the rotating type especially interfere with the general trend of air circulation. When the humidity is high they help in removing the air enveloped around the body allowing air not so saturated to evaporate moisture.

Ceiling fans are more comfortable—they do not produce such violent drafts. They are especially to be recommended in wide houses in summer time to assist mechanical ventilation.

All of the ceiling ventilators may be connected by ducts to one discharge through a blower. In this way ducts of any size or length may be used and still be assured of positive exhaust. A direct connected one has many advantages over the belted type. They may be located where belted installations are impossible, they use less power, and run more quietly.

As before mentioned, all of these systems provide for the exhaust of air only and heating is through direct radiation of the furnace.

Exhaust Ventilation.

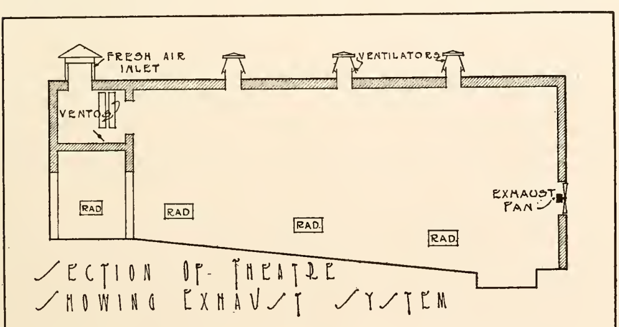
Intimately connected with the subject of ventilation is the problem of maintaining air of a certain standard of purity. The introduction of pure air can only be done properly in connection

with a system of heating, and likewise any system of heating is incomplete and imperfect which does not supply a proper supply of air.

Mechanical ventilation in connection with the heating may be of two types, the exhaust and the plenum system. The exhaust system will be taken up first, and the plenum second.

The exhaust system is very elastic, and each house should be studied separately and carefully in order to produce the best results. In the illustration one example of this system is presented. The principle of the system is as follows: The air is exhausted from the auditorium by mean of propeller fans or a blower. This creates a lower pressure in the auditorium than in the outside air, and consequently air will be drawn in through the openings to replace that drawn out. Because of the absence of windows in a theater, air will be drawn in through the doors and fresh air openings only. In summer this will be satisfactory, but in winter the cold air will be objectionable. In order to introduce heated air through the fresh air openings, vento stacks or indirect steam radiators are placed in front of the openings into the auditorium. The air drawn over these heated tempering coils is then introduced into the theater at comfortable temperature. Air drawn in through the doors will be heated by radiators placed in the lobby.

A by-pass with a controlling damper is placed under the vent coils so that unheated air may be drawn in when desired. This is desirable in summer and when the weather is moderate.



SECTION OF THEATRE SHOWING EXHAUST SYSTEM

Referring to the illustration, the fresh air intake is located over the entrance lobby. On both sides of the operating booth an air chamber is placed. A double stack of indirect radiators or vento stack is placed in front of the opening into the auditorium. The by-pass damper is shown beneath the vento stacks.

Radiators are placed in the lobby and along the walls of the auditorium near the floor line. If the side walls of the theater are back of the lot line, fresh air inlets may be placed in back of the radiators, making them semi-indirect, with a fresh air box underneath. It is understood with this system that the direct radiators will supply all of the heat necessary to keep the air in the theater at the desired temperature, while the vento stacks take care of the fresh air introduced.

One or two exhaust fans are placed about seven feet above the floor at the screen end. When these are in operation fresh air will be drawn through the intake over the vento stacks down into the auditorium. The air will travel through the length of the house and be exhausted by means of the fan. Foul air near the ceiling will be exhausted through the roof ventilators. The siphon type mentioned is preferable, as it does not allow a down draft.

This system is probably the most economical for a small house. As stated above, it may be modified in several ways. In order to make the delivery of fresh air into the theater more positive, and also of a certain amount, a propeller fan should be placed in the opening between the vento stacks and the auditorium. In this case the exhaust at the screen end may be dispensed with, the foul air being exhausted by gravity alone.

Also a number of registers may be placed near the ceiling line and a duct system connecting them together and leading to one outlet through a blower. The use of ducts will make the system more expensive, and in such a case the plenum system may be more satisfactory.

The Plenum System

Without a doubt the best system for the heating and ventilation of theater auditoriums is what is known as the plenum system or forced draft system. Whenever a certain amount of air at a certain temperature must be supplied to any room the only certain

way is to force the air into the room. Because of the many devices, such as air washers, coolers and humidifiers, which may be used successfully with this system, it is much more desirable than the exhaust system mentioned.

The system contemplates the use of the following distinct elements: First, a fresh air intake; second, some form of hot metallic surface over which the fresh air which has been introduced into the chamber may pass and be heated; third, a blower or fan to force the air into the ducts; and fourth, an arrangement of ducts to distribute the heated air to the desired locations.

The fresh air intake should be located so as not to be liable to contamination from smoke, dust or gases, from soil stacks or odors from refuse cans or boxes. It should never be less than ten feet above the grade line. Even when an air washer is used it is preferable to take the air from a high intake instead of at grade level.

The fresh air then passes over the heating coils. The best form of coil now in use is the vent cast iron section. These have projections on them at right angles to the face. The air in passing between these sections is broken up by these small projections, heating it more readily than with the old coil type. In this system, as adapted to theaters, the air introduced is only heated to that temperature required in the auditorium, or slightly higher if the ducts are very long. Direct radiation is then used in the auditorium to supplement this, that is, to take care of the loss of heat through walls and openings. A by-pass is placed around the coils for use in warm weather, when it is not necessary to heat the air. The heated air is then drawn into the fan, which is usually of the centrifugal or blower type. The air enters the side inlet and is delivered at the edge of the blades. This fan is always used with a housing and can be obtained with an air delivery in any direction. A motor directly connected to the fan is much more satisfactory than the belted type. There is less noise from the motor, as it is at a lower speed, also less noise and trouble than from belted connections.

In a theater the plenum or mixing chamber is usually dispensed with, and the fan delivers the heated air directly into the ducts.

There are two methods of air introduction in common use today. With one system long parallel ducts are placed under the floor and a number of small openings with cast iron covers called mushrooms are placed in the floor under the seats. These mushrooms are provided with adjustable tops for controlling the amount of air from each. In using these the velocity of the air air must be very low, as it blows directly on the feet of the patrons. If the house has a balcony a duct should lead from the fan to the ducts under the balcony. Registers can be placed in the side of the balcony steppings.

The mushrooms are objectionable from a sanitary standpoint. They are not easily kept clean and naturally may become a source of foul odors. As the velocity must be kept down, a large number of outlets are required, making this system more expensive than the side wall register type.

With the latter system, ducts are run from the fan under the floor along the side walls of the auditorium. Vertical ducts connect with the registers on the walls. These registers may be placed from six to ten feet above the floor. The higher they are placed above the floor the greater may be the velocity of the entering air, as it is less liable to disturb patrons. When the ceiling is not over fifteen feet high, air may be introduced through ceiling registers. Wall registers should never be placed on rear walls; that is, the wall at the people's back, unless the velocity is extremely low and the ducts at least ten feet up. Furthermore, introducing air at this end and withdrawing it at the screen end interferes with the acoustics of the auditorium. Large register faces may be placed on the sides of the screen very economically if the boiler is located nearby.

Exhaust or vent outlets should be located at the floor lines of the side and rear walls when fresh air is introduced at the side walls. These outlets lead into ducts about eight feet high, which discharge into the open air. With this system the space above the heated air inlets should be air-tight.

With the mushroom type the air is exhausted through ceiling ventilators, which may terminate directly into roof ventilators, or be connected with a large duct having an exhaust blower at the end to discharge into the open air.

Supplementary mechanical devices for use in connection with the plenum system will now be considered.

The dangers of dust contamination have already been mentioned. Dust is not merely an inconvenience, as was formerly supposed, but it also gives rise to objectionable odors or deleterious substances when decomposed by the heaters. It also irritates the mucous membrane of the lungs and respiratory passages, rendering them more susceptible to the germs of disease. Therefore it is plain that air washers or other means of dust removal must come into universal use in city work.

Air Washers

Also it is desirable to control the relative humidity or amount of moisture of the air forced into the theatre. We are all aware how important the proper humidity is for comfort, and from the standpoint of health it is important that we realize fully the bad effects of low humidities maintained in cold weather, and also the depressing effects of high humidities in moderate weather.

An efficient air washer and humidifier with devices for automatic humidity control is another thing in favor of the air washer. Also in hot weather the temperature of the introduced air may be lowered several degrees by use of the washer, and if the spray is considerably cooled the temperature of the air will be correspondingly lowered. The plenum system as already discussed, lends itself very readily to the use of an air washer. A purifier usually contemplates the installation of two parts, a washer and an eliminator or extractor. The washer consists ensentially of an air duct, located immediately behind the tempering coils, and provided with streams or sprays of water through which the air must pass. Having caught the dust particles and disolved the soluble gases from the air, the water falls to a collecting pan at the bottom of the spray chamber and from there is again pumped through the spraying nozzles. As the water becomes too dirty or too warm a fresh supply is delivered to the collecting pan. A small centrifugal pump is usually used for the circulation of the spray water.

After passing through the washer the air next encounters the extractors, the purpose of which is to remove or eliminate the

surface moisture and water particles remaining suspended in the air. This is accomplished by an arrangement of more or less complicated baffle plates, which causes the air to change its direction suddenly many times in succession, with the effect that the water particles impinge upon and adhere to the baffle plates. These are suitably drained to the collecting pan beneath the washer. As the air leaves the eliminator and enters the fan it may be relieved, with good apparatus, of 98 per cent of all dust and dirt, may be supplied with moisture to very near the saturation point, and, in summer time under favorable conditions, may be cooled from 5 to 10 degrees lower than the atmosphere. This is due to the cooling effect of vaporizing part of the water.

Special air cooling plants have been installed in connection with the plenum system of ventilation, whereby a refrigerating brine may be circulated in the regular heating coils.

Relative humidity is the ratio of the weight of moisture contained in a given quantity of air to the total weight of moisture that the same quantity of air will retain when fully saturated. Air is said to be saturated when it contains the maximum amount of water vapor possible. The higher the temperature the more water vapor it will hold in suspension. The effect of a low humidity is to cause the body to feel cold even in a comparatively warm room. This is because the dry air produces a rapid evaporation of the moisture from the body producing a sensation of cold. On the other hand when air is saturated no evaporation can take place. Consequently a humidity of the correct amount and constantly or automatically maintained at that amount is highly desirable.

If, therefore, incoming air is partially heated by the tempering coils, then saturated by passing it through the water spray of the washer, then heating it up to the desired room temperature, the humidity may, by this process of heating above the temperature of saturation, be lowered to the proper amount. Thus is automatic humidity possible. For comfort a humidity of 50% with a temperature of 68 degrees is best.

INVESTIGATION OF SAFETY GOGGLES AT UNDERWRITERS' LABORATORIES

BY SIDNEY V. JAMES*

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Although Underwriters' Laboratories have been for some time actively engaged in the examination and testing of devices having a bearing on the fire hazards to property, it has been only a short time since their activities have broadened so that now work is being done to standardize appliances used in preventing accidents. Manufacturers of such appliances submit them to the Laboratories for examination and test so that if found to be standard or equivalent thereto in every respect they may secure the benefits of the label service now in force in many industries. One of the numerous branches of this new field of endeavor is the investigation of goggles used by workmen as a protection against injuries to their most valuable asset, their eyes.

There are in general two broad classes into which goggles for industrial purposes may be divided. These divisions are based on the amount and kind of protection required. The first class is composed of goggles intended to be worn by men engaged in some of the many forms of ordinary shop work such, for example, as grinding, chipping, lathe or other machine tool operations, babbitting of bearings, cutting off rivet heads, etc., and such goggles must prevent eye injuries due to the impact and entrance of particles of material liable to be suddenly and unexpectedly thrown off from the work. The second class is composed of goggles intended to be worn by men engaged in welding and cutting of metals by the various devices ordinarily employed, such as the oxy-acetylene torch, and also as a protection to the eyes of workers around furnaces and other sources of intense radiant energy.

The principal phases of the investigation of goggles by Underwriters' Laboratories will now be taken up, including the reasons for considering each item as well as means of determining the necessary information upon which conclusions are based.

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*Class of 1907

Let us take up a consideration of the first class known at the Laboratories as Type I goggles. Fig. 1 shows a pair of such goggles being worn. It is of prime importance that they be comfortable in order that the workmen can be induced to use them continuously for long periods of time. Hence, comfort tests are made, various experimenters each wearing a pair of the goggles for at least one hour and noting the degree of comfort. The total weight is an element of interest and it is found that when in excess of about 2½ ozs. it will make the goggles uncomfortably heavy.

Fig. 1.

It is also essential that the goggles fit the wearer closely so as to prevent foreign particles from reaching the eye between the edges of the frame and the wearer's face. This is noted at the time comfort tests are made and the adaptability of the frame by adjustment to various types of face is noted. Some of the earlier and inferior goggles, although easily fitted to normal faces, would not, as sometimes called upon to do, fit "a face like a cow," as some of the users express it.

Another phase of the work is the consideration of the sterilization of goggles. Frequently some man will lend another his goggles, even though it is recognized as a bad practice. In some shops it is customary to hang up a pair of goggles near a grinding machine and intend them to be used by whoever uses the machine. These possibilities necessitate that goggles be of such

material and construction that they may be readily sterilized. This is usually accomplished by immersion in boiling water or a steam bath, hence the parts are subjected not only to sudden changes of temperature but also to temperatures in the neighborhood of 212 deg. F. Tests are, therefore, made by suddenly immersing test specimens in boiling water after first leaving them in water at a temperature of 60 deg. F. for a time long enough for them to acquire the temperature of their surroundings. Standard goggles will successfully pass this test.

Each pair of standard goggles is marked with the name or initials of the manufacturer and some distinguishing type or trade letter or number. Such a precaution enables standard articles to be identified in service.

The frames of these goggles are subjected to corrosion tests by being immersed in a water solution containing 10% by weight of salt. Samples are kept in the solution for a period of 24 hours and after removal are carefully examined for effects of corrosion. Such tests bring out the ability of the frames to withstand corrosive effects of perspiration and other fluids liable to be emitted by the skin of the wearer.

Frames, if intended to be stiff, must also have the proper amount of stiffness so that they will hold their shape when once adjusted and fitted to the individual wearer. In order to determine this matter, the frames of the stiff type must withstand, without permanent set, the following tests: (1) Eight ounce load applied perpendicular to the plane of the lens. The right lens is laid and held flat on a table top with the nose bridge and left lens projecting beyond the edge of the table. A spring balance is connected to the outermost portion of the frame around the left lens and a force of 8 ounces exerted in a vertically upward direction. (2) Four pound load applied in the plans of the lens. The right lens is held vertically in the hand and the lower edge of the left lens frame pressed against the center of the pan of a balance carrying a 4-pound weight on the opposite pan. Pressure is then exerted on the balance so that the 4-pound weight is lifted.

The design and construction of the frames must be such that the lenses when broken may be easily replaced and the lenses

firmly held in position when inserted. Side guards or shields are usually furnished and are intended to offer protection from particles approaching at the side. They are carefully examined to see that they do not obstruct side vision like blinds since it is important for a workman to quickly become aware of the approach of danger from the sides. Leather side shields would not, unless perforated, permit this advantage, but such shields, unless easily replacable, are not permissible since they are not readily sterilized.

Lenses for such goggles should be constructed of clear colorless glass free from air bubbles, flaws and other imperfections, such as would obstruct the vision. They should be ground on both sides and possess a high degree of uniformity in thickness. All such items are determined by examination and measurement of the samples submitted.

The strength of lenses is highly important. Rivet heads, large chips of metal and the like may strike such lenses and it is, therefore, important to test them for strength in this way. The standard drop test machine now in use consists of a magnetic support block for suspending a ⅝-inch steel ball at a height of 21 inches above the sample to be tested, the latter being mounted on a standard rubber-cushioned block or anvil. Each lens is subjected to 25 blows unless failure occurs before this number is completed. Standard lenses will resist without cracking or splintering a total of 25 blows. Any evidence of chips being knocked off the eye side of the lens will disqualify it at once.

Strength to resist the effects of sudden splashes of hot metal such as might occur during babbitting or soldering operations is also very desirable. Tests are made by dropping grams of molten lead from a height of 18 inches upon each lens three times in succession. Lenses must resist such treatment without cracking or ejecting chips from the eye side.

Goggles of Type II are intended for use where it is desirable to protect the eyes of the wearer from the harmful and fatiguing effects of intense radiant energy as well as from mechanical injury due to splashes of hot metal or small flying particles of materials with which or near which the wearer has to work. Injurious effects are produced by excessive amounts of either

infra-red rays, visible rays or ultra violet rays and such radiant energy is always present to a greater or less degree in such industial light and heat sources such as electric arc or oxy-acetylene welding and cutting flames, furnaces of various kinds and short-circuit flashes occurring in electrical work. Fig. 2 shows a pair of Type II goggles.

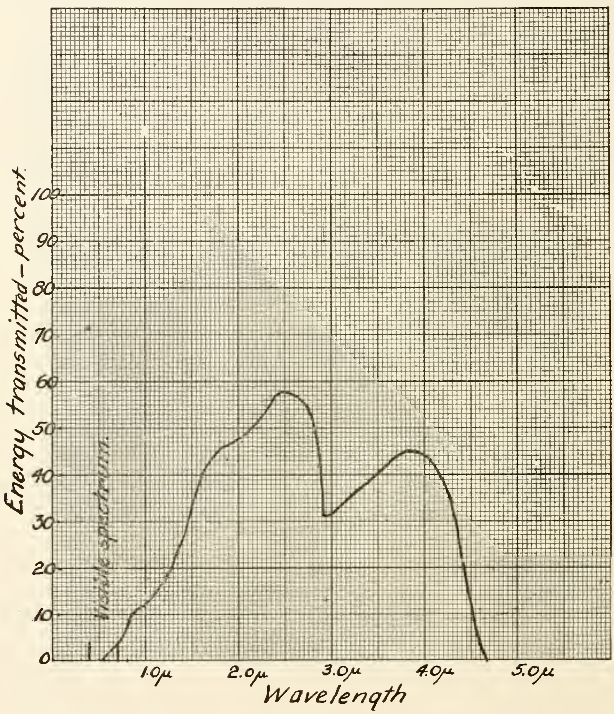
The general desirable features of Type II goggles with regard to comfort, adjustability of pupilary distance, fit, sterilizability, replaceability of lenses and marking are the same as those already outlined in connection with Type I goggles and are determined at the Laboratories by the same procedure of examination and tests.

Fig. 2.

The most important phase of the investigation of such goggles is the examination and testing of the lenses. These should, of course, be made of material of good optical quality and should be reasonably free from air bubbles. The surfaces should be plane and parallel to each other within a reasonable degree of uniformity determined by micrometer measurements of the thickness of the lens taken at not less than five different places. Such lenses should also be uniform as to external diameter and edge bevel so as to be readily interchangeable or replaceable.

The spectral transmission of lenses is made the subject of special study because of the serious results due to exposure of the eyes of workmen to the harmful radiation emitted by indus-

trial sources. The infra-red rays or heat rays have a detrimental effect besides the discomfort due to the heat, hence it is well to provide a glass which transmits only a limited amount of infra-red. Determinations are made by measuring the relative amount



of energy transmitted at various wave lengths throughout the spectrum and extending the readings to wave lengths up to about 5.0 u. For this work the radiation transmitted is analized by a fluorite or rock salt prism and a spectro-radiometer, the sample under test being placed between the source of radiation (at a temperature of 1,000 deg. C.) and the spectrometer slit. Fig. 3 shows a diagram for a typical goggle lens, the curve being car-

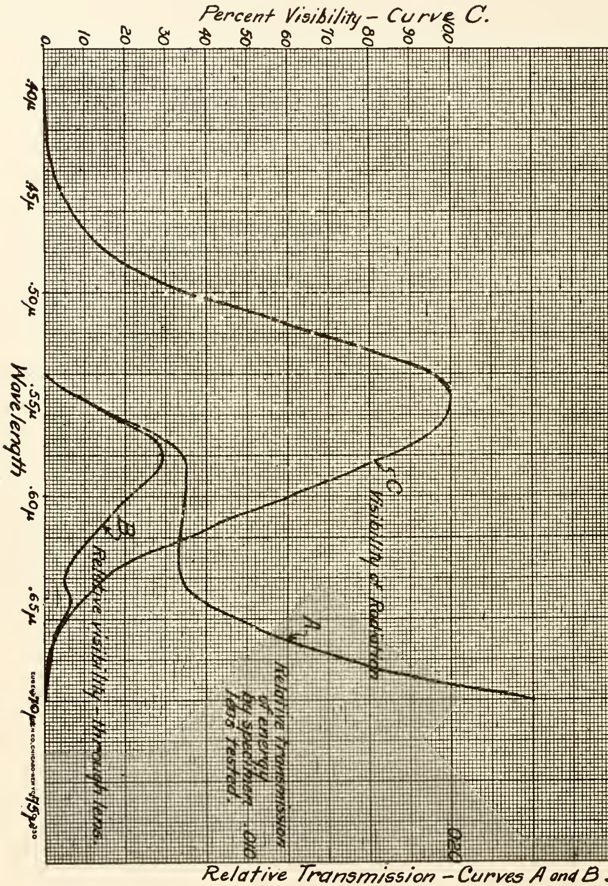
ried out to between 4 and 5 u. where it drops to zero. From such a curve, the percentage of total heat transmitted is determined by measuring the area under the curve and expressing it as a percentage of the total area up to a transmission of 100%. The curve shown gives a value of 33% for radiation up to a wave length of 4.65 u.

In the visible spectrum, tests are made by means of an ordinary spectro-photometer and the transmission of visible radiation, or in other words, light transmitted, is determined. Such information may also be determined from an enlarged diagram of the total energy transmission in the visible spectrum. Fig. 4, curve A, shows such a curve, while curve B was obtained from it by multiplying each ordinate by the radiation visibility percentage is given by Nutting (Bureau of Standards) and indicated by curve C. The area under curve B expressed as a percentage as given by Nutting (Bureau of Standards) and indirepresenting 100% transmission will give the light transmission. This valve for curve B is about 0.12%.

The injurious effects of ultra-violet radiation on the eye are well recognized. Some authorities (Verhoeff and Bell, "Science," Sept. 25, 1914, pp. 452 to 455) have stated that abiotic action for living tissues is confined to wave lengths shorter than 305 u u, while others (among whom is Nutting, Bureau of Standards, Circular No. 38) claim that fatiguing effects are produced by wave lengths of 365 u u or shorter. The Laboratories have decided that Standard Type II goggles should prevent passage of all ultra-violet radiation of wave lengths shorter than 365 u u and tests are made by photographing the spectrum of an iron or carbon arc produced by a quartz spectograph after insertthe test lens between the arc and the slit and determining by examination of the negatives whether or not any radiation below wave length 365 u u has been transmitted.

In addition to the above tests, Type II goggles are submitted to hot metal and hot water tests exactly as outlined under the discussion of Type I goggles above.

Special attention is paid to the eye-cups or lens mountings for Type II goggles to determine whether or not they are designed so as to ventilate properly. It is important that "sweating" of


Percent Visibility - Curve C.
0.
10.
20
30
40
50
60
70
80
90
100
.40μ
.45μ
.50μ
.55μ
.60μ
.65μ
.70μ
.75μ
Wavelength
C
Visibility of Radiation
B
Relative visibility - through lens.
A
Relative Transmission of energy by specimen lens tested.
.010
.020
Relative Transmission - Curves A and B.

the inner surfaces of the lenses does not occur to such a disagreeable degree as to hinder vision or render the wearing of such goggles uncomfortable. Arrangements for proper ventilation should also be such that no unprotected openings large enough to allow foreign particles of a size sufficient to cause eye injury to enter. It is not the intention to prevent entry of finely divided materials such as dust since special precautions required to overcome this difficulty are rarely necessary in industrial work of such a nature that goggles only are sufficient protection. When dust is present in quantities great enough to produce irritation or injury, a helmet or mask should be worn.

The eye cups or lens mountings should be capable of resisting ordinary rough usage such as they are liable to receive in the hands of ordinary workmen. To this end examinations and rough usage tests, as well as a consideration of the known properties of the materials employed, serve to bring out the necessary information.

It will be seen, by the above brief mention of the various items taken into account, that the examination and testing of goggles covers a broad field and requires the use of accurate and expensive apparatus. The Laboratories have been serving some of the largest goggle manufacturers along these lines and reports from the field indicate the usefulness of such investigations.

The Armour Engineer

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This, the first issue of Volume IX of *The Armour Engineer,* comes to you as the result of the efforts of a new staff which has striven to place this journal in the foremost rank of technical college publications. In this attempt, the demand of the undergraduate body for a section devoted to student activities has not been met. Such a section would tend to lower the standard

of the journal from its technical sphere to that of a mere college paper. The present staff is in sympathy with the student body in their demand, but hopes that they fully realize that to publish such news is the function of a college paper and not of *The Armour Engineer.*

The policy of previous years to publish articles of a high standard and excellency, written principally by our Alumni and members of our Faculty, will be continued. A more extensive department of "College Notes" has been added, giving the activities of each department as well as information concerning the Institute, of general interest to both our Alumni and undergraduate body. May this section be welcomed by our readers! *The Armour Engineer* owes its existence primarily to the Alumni and Faculty. Therefore, we extend our sincere thanks to them for their support, which is greatly appreciated by their Alma Mater and by the editors.

OPPORTUNITY

The institution which this publication represents is to be congratulated in having the privilege and responsibility of a national convention of young men all associated with those branches of collegiate life devoted to the upbuilding of the Technical Arts. The mere fact that a group of representatives of one association from various colleges chose Chicago for the scene of annual hilarity bears no significance whatever. The real purpose, the essential spirit back of it all, is not in evidence to the outsider—not even to many engineers unfamiliar with the purpose of this young group of thinkers.

These men are endeavoring to create a new era in the life of the engineer, to forge a stronger framework upon which his ethical position in a community with other forceful natures and highly developed minds may be determined and achieved. In so doing they are not indulging in weazel-words and pussy-footing, but are endeavoring to put into practice first, man-fashion, the principles for which they stand—then spread the leaven broadcast.

I will refer to but three phases of this movement that appear to me paramount issues, passing by entirely the supreme value of association with men of kindred caliber, understanding and moral courage.

First: The relation of the Engineer to the Public and his appreciation of the opportunities for public service.

Second: The necessity of a higher ethical standard in the professional as an essential to the public selection and acceptance of the engineer for responsible public stewardship.

Third: The great opportunity for the engineer to revitalize the industries of the country on a basis of economic efficiency, financial integrity and justice to employer and employee alike—as in matters of controversy such as have already shaken the foundations of democrarcy.

Now these premises are not high-blown dandelion blossoms, they are serious facts. A great New York banker sends his son to be trained for business at a middle-west engineering college. Why? Why not to the "Old-line University" where all the fanciful traditions of his own college days would be lived over again by his son? Why select the great university of the middle west, strong in its free, active, virile spirit of true democracy? Again our American cities often find themselves wallowing hopelessly in a three-cornered fight between the city political heads, the utility corporation and the radical-minded public. Years are consumed over technicalities of law with the inevitable result—attrition of civic purpose. Why is the engineer called in to administer the pills for their sinking spells (or sinking funds, so to speak), for dictating terms of franchises and charter amendments, methods of accounting, investment of funds, equitable division of profits and many other functions usually supposed to be quite beyond the engineer's vision? And still again—looking into the future—face to face as we are to the distressing situation of temporary material surfeit on the one hand and on the other the utter unconcern over the national dangers that beset us from internecine of external warfare, "peaceful" or otherwise, what single one may be looked to for relief?

The answer seems to me to be—National Idealism and National Efficiency, not singly but jointly for a single purpose—National Worth, National Security (not national power). Here is a plea for strong personalities—men of understanding and keen perception for discriminating between Truth and Error. Here is the final test of the Engineer wherein his ethical standards, first, his conceptions of political economy, second, his technical knowl-

edge, third and last, find full play. He knows how and where to challenge distorted facts and specious arguments, when to discuss principles and when details, how to look at the future and construct out of cold mathematics a vision of cities, industries, continents if you please—visions which have every chance of realization—barring acts of God or the ruthlessness of man's hand and heart.

There are many preaching discontent with the lot of the Engineer. True, but let us have deeds, not words, real men, not mummers, thinkers, not pencil-pushers.

This challenge is thrown out to the world by the young men who have faith in their profession. The strength of the hills slumbers in the leaven that is gradually turning them to the Halls of Science. But let it not be cold calculating science of the kind that enervates the Spirit while it builds its Tower of Babel.

J. Rowland Bibbins.
Pres. Michigan Engineers of Chicago.

The fact that there are other things besides a purely technical knowledge which go to make up the successful engineer was very forcibly brought out in the address of Prof. C. Francis Harding of the Purdue University, head of the Electrical Engineering Department, on "Marketing Engineering Ability," presented at the Second Annual Booster Dinner of the rapidly growing American Association of Engineers on October 6, 1916, at the City Club, Chicago. The main points of his address are given in the following portion quoted:

"First, it may be said, convince the young engineer of the importance of *good written Engish* and the necessity of clear and verbal presentation of his recommendations to non-technical individual or audience. It has been well said 'you can please, you can plead, you can instruct, you can command or you can rebuke, in each case with the right use of words, and the right degree of emphasis, if you can use correctly the English language.———'

"Whereas a mastery of both spoken and written English is more readily recognized as a vital agent which the successful engineer must command, a thorough knowledge should be acquired of *business principles* with which his audience is too

often more conversant than himself. Who shall interpret into the language of dollars and cents the estimates and findings of the engineer? Can anyone but he analyze as intelligently the valuation upon which the corporation is to base its rate schedules? Surely no one will question the justification of such a one suggesting to commission or court the fair and equitable gross income which should be allowed a railway corporation in order that it may pay a reasonable dividend upon its stock, when he is perhaps more conversant than anyone else with the construction, operating problems and costs of the particular utility in question. But the average young engineer knows little or nothing about rates, dividends, capitalization, stocks, bonds, etc. But what is worse, many consider it none of their affair. Such are likely to make an adverse criticism of the status of the engineering profession their first matter of business. *An estimate of the cost of an engineering project often forms the connecting link between the business world and the engineer.* The business manager, the banker, courts and commissions judge the engineer by the portion of his work with which they are familiar i. e., estimated costs of construction, court testimony or appraisals of property."

"*Accounting practice* and the proper treatment of depreciation reserves should be matters of common knowledge to the engineer. Who can say but what many of the financial disasters in the railroad history of the country might have been avoided had the engineers been sufficiently cognizant of the reserves which should have been set aside to provide for the evil day in which the depreciation curve which has gradually been recording the decay of equipment, suddenly lowers the valuation of the property by leaps and bounds. Should not the young engineers who will soon be estimating the operating expense of electrification in Chicago, for instance, know something of the effects that an error in calculation or judgment may have upon the dividends which such a road may pay upon invested capital?

"Business knowledge, however, even when coupled with a command of one's mother tongue would fall short of the market demands upon the engineer without the necessary *tact* which must be exercised in all relations with the public. * * *

"The executive quite often fills the gap between the engineering department and the board of directors or the public. He acts as the buffer to receive the rough edges of the average engineering report, and to polish its surfaces that they may make better contact with the layman and the financier. Unfortunately he must frequently stand upon the fence picking the rough burrs from the tree of scientific investigation which he must laboriously open before the tender kernels of opportunity for investment are disclosed. The term "executive ability" has come to mean "marketing ability" in many corporations. It is a comprehensive quality involving many of the factors previously discussed. It has been well defined as "The ability to get others to do what they wish most to accomplish."

"It was said of the late George Westinghouse, "he is in control of enormous manufacturing companies in both hemispheres. The world is his field. No routine duties in any of his score of companies sap his energy. *He thinks, others act.* More than that, he inspires, and a hundred-thousand act. Some of his great spirit filters down through all of the organization, yet each man has his area of responsibility, in which he is perfectly free to follow his own work in his own way. Such a policy develops men, broadens them, fits them for higher duties, and secures the realization of a great man's ideal. It fits other men, including their wills, in the execution of one's plan." Yet George Westinghouse was an engineer, first, last and always. There are many such in executive office in this day. The number is rapidly increasing. Whereas we may grant for the sake of argument, the claim of sceptics that executive ability is born and not made, it must be admitted that such a quality is often latent and lies dormant for years in many a human system."

The Bureau of Standards has issued some new publications, three of which are here described:

Electric Units and Standards: This publication gives comprehensive and up-to-date information regarding the units and standards in terms of which electric and magnetic measurements are made. It includes the history of the units and the evolution of the definitions upon which the laws of electrical standards are based. The laws of this and other countries are given. These

laws are in substantial agreement, and the various national bureaus of standards co-operate in maintaining the fundamental standards. The circular gives conversion factors, by means of which measurements may be expressed in any desired unit. The information on electric units and standards had not previously been available in a single publication.

The Determination of Aluminum as Oxide. This paper gives the results of a research to define the conditions for the determination of aluminum. From observations made with a hydrogen electrode and with suitable indicators, the conditions for the quantitative precipitation of aluminum hydroxide by ammonium hydroxide were determined. In practice the completion of precipitation may be defined by means of methyl red or of rosolic acid. The effect of various factors upon the precipitation, washing and ignition of the precipitate was determined. The procedure for obtaining accurate results is also described.

Properties of Some European Plastic Fire Clays. In the manufacture of glass pots, tank blocks, glass furnace accessories, graphite crucibles, and similar refractories, a certain amount of plastic clay is required for the purpose of bonding together the grains of calcined material, ground potsherds, and previously burned fire clay, which constitute from 50 to 60 per cent of the mixture used.

The requirements of such clays are very exacting and may be summarized as follows:

First, they must possess sufficient refractoriness to withstand the high heat of the furnaces, under the pressure of the liquid charge, without showing deformation; second, great plasticity and bonding power, making possible the cementing together of the grains of calcined material to a satisfactory compact mass; third, considerable mechanical strength and toughness, especially in the dried state; fourth, the quality of becoming dense at comparatively low temperatures in order to produce a structure impervious to the liquid glass or metal and resisting their corroding influence; fifth, the property of retaining a sound structure, free from vesicular development upon long-continued heating; sixth, the quality of resisting sudden temperature changes without checking or spalling; seventh, the property of drying and firing safely without cracking.

These requirements are severe and are possessed by comparatively few clays. The materials which have been found most satisfactory by years of practical experience are a number of European clays, principally those from Gross Almerode, Klingenberg, Schippach, and the Westerwald district in Germany, from Belforce and the Ardennes region in Belgium, and from the Stourbridge district in England. These clays possess the properties demanded of glass refractories to a marked degree. It would seem desirable, therefore, to investigate their properties in order that a basis of comparison be established, enabling us to estimate the value of domestic clays for the same purpose. Such results should be of particular importance at the present time when shipments of European clays are uncertain, with the prospects of ceasing entirely.

After an absense of three years, courses in languages have been resumed at Armour. The courses are strictly optional. Mr. Wm. C. Doub-Kerr has been appointed instructor in modern languages and has organized classes in French and Spanish.

Prof. Scherger has consented to teach classes in Scientific German.

From the interest shown in these courses, it is evident that a long felt want has been satisfied.

A supplement to this issue will contain a complete index of Volumes I to VIII, inclusive, of The Armour Engineer. This is the first year that an index of this character has been published, and it will undoubtedly prove valuable to our subscribers. Much credit is to be given to Miss Ellyn C. Broomell, Ph. B., assistant librarian, who, of her own volition, has carefully compiled this complete index.

DEPARTMENT OF MECHANICAL ENGINEERING

An appropriation has been made for equipping the boiler room of the Institute with a test board upon which will be mounted all the necessary indicating and recording instruments. Plans are now well under way for the installation and it is hoped that they will be completed in the near future. It is the plan to have all Seniors operate the boiler and the engines, and to become familiar with the necessary regulations as indicated by the recording instruments.

The shops are building a complete line of water dynamometers, and testing machines of the Department's own design. It represents an outlay of about $2500 a year.

Asst Profs. Anderson and Peebles are making comprehensive physical tests of samples of underwear from Stevenson and Company.

Most of the acquisitions have been in the department of Automobile Engineering. The apparatus now consists of: a Packard Twin Six engine; a Chalmer's 3400 r. p. m. six cylinder engine; a Buda eight cylinder engine; a Ford engine equipped with a Gray and Davis starting system; a Teetor four clyinder engine; two four cylinder Rutenber engines; a Harley-Davidson high speed twin cylinder motorcycle engine connected to a 4500 r. p. m. electric dynamometer; a Wimperis recording type accelerometer; and a Tracy reaction dynamometer.

Associate Prof. D. Roesch will present a paper on "A New Method of Engine Testing" before the Mid-West Section of the Society of Automobile Engineers on the evening of December 7th. This meeting is to be held at Armour Institute.

Mr. Harry G. D. Nutting has been added to the teaching staff of the Department of Mechanical Engineering in the capacity of Instructor in Gas Engineering Laboratory. He graduated from the University of Illinois in 1906, and up until this year has been a consulting engineer. He has also had considerable experience in gas engine work, having been associated with several large gas engine concerns.

Assistant Prof. Peebles has been conducting work on thermal conductivity in the Mechanical Laboratories with the object of developing a method for the determination of thermal conductivity of building materials which would be more accurate and convenient than the ice-melting method. An electrical device has been constructed in the Institute which has given very satisfactory results in determining heat flow through building paper, cloth, plaster board, cork board, lith, clay tile, gypsum tile, and similar materials of construction.

DEPARTMENT OF ELECTRICAL ENGINEERING

Two new instruments have been added to the apparatus of this department. They are an Eidograph and Integraph. The former is used for enlarging or reducing drawings. It is to be used chiefly in power plant work where they desire to have all of their drawings on the scale of one-fourth of an inch to a foot. The latter is a mechanical integrator, useful in solving graphical problems in electric railway work. It draws the integral curve of another curve; i. e., if the sine curve were traced the Integraph would draw the cosine curve.

DEPARTMENT OF CHEMICAL ENGINEERING.

Professor McCormack has designed and is now installing a plant for the production of Benzoic Acid from Toluene. Prior

to this, he designed, built and operated the plant of the Chattanooga Chemical Company, and is now working on processes for the production of Resorcin and Phenolphthalein in commercial quantities.

Some research work has been done on manufacturing chemical problems by members of the department within the past few months.

Associate Professors Doubt and Freud have been doing some work on the application of the "interferential constant" values of organic compounds of similar thermodynamic environment.

Associate Professor Freud is working on the design and construction of apparatus for manufacture of the various sulphur and sulphur chloride addition products of the different vegetable oils for use in compounding rubber.

DEPARTMENT OF FIRE PROTECTION ENGINEERING

Prof. F. Taylor has resigned as head of the Department of Fire Protection Engineering to devote all of his time to his position as Consulting Engineer for the Underwriters' Laboratories. Prof. J. B. Finnegan has succeeded Prof. Taylor as the head of the department with Mr. H. H. Allport of the Hydraulic Department of the Underwriters' Laboratories as instructor of the work at the Laboratories. Prof. Taylor will act in the capacity of special lecturer for the department.

DEPARTMENT OF ARCHITECTURE

Prof. Shattuck has resigned as head of the Department of Architecture to devote all of his time to his rapidly growing business. Prof. E. S. Campbell is acting head of the Department.

Mr. J. V. Richards has been secured as instructor in architectural construction. Mr. Richards is a practising architect with offices in the People's Gas Building.

Mr. Louis H. Sullivan, designer of the auditorium for the Transportation Building and of other important buildings at the World's Fair, and one of the leading architects of America, has been secured as special lecturer in this department. This should appeal to all who are interested in architectural education, for Mr. Sullivan is a man of international reputation. His lectures will certainly prove to be of unusual interest.

The course in Graphic Statics and Steel Construction, formerly taught at the Art Institute, is now taken care of by the Civil Engineering Department. Associate Prof. Wells has the course of Graphic Statics and Architectural Engineering, while Assistant Prof. Penn has taken the classes in Steel Construction.

Two fair co-eds are now enrolled in this department. Their names are: Miss Eleanor Van Vlissingen, and Miss Laura Denton. Miss Van Vlissingen intends to complete the regualr four year course, while Miss Denton is pursuing a special course at the Art Institute.

The evening class attendance at the Institute has reached the highest mark in the history of Armour Institute. The number of students reaches the 800 mark, the maximum number that can be taken care of, with a waiting list of men eager to enroll in the courses. This speaks well for Armour, since similar courses are offered in Chicago Public Evening Schools, and in other institutions charging less for the same courses. No attempt is made in the evening classes to duplicate the work of the day school, although certain subjects, such as mathematics, drawing, and shop work receive equivalent credit in the curricula of the day classes. Many students in the evening classes are preparing to take the regular college courses in the near future.

Another fact to be noted at the Institute is that more advanced students are entering from other colleges of high standard than before.

SUMMER CAMP

Field practice in Surveying for the Civil Engineers began on June 2nd and ended on July 15th. Twenty students including twelve Seniors, four Juniors, and four Sophomores participated. Rain hindered the work in the beginning of the course, but the weather in July was all that could be desired.

Practice with the tape, level, transit, plane table and theodolite succeeded one another as in previous years. The stadia survey

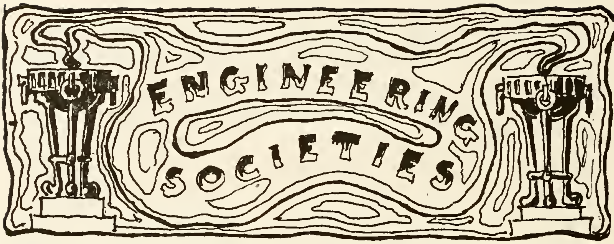
and plane table work included the Wisconsin Conservation Commission grounds and buildings, their pine tree nursery, and the Point, extending from camp southward one half mile and westward to the shore of the Lake. Each polygon was balanced in camp and the traverses are now being plotted.

Three triangle towers were built by the students, one in camp and two on the northwest shore of the upper Lake. A new base line was established and measured, but a good location for a permanent one has not yet been found. A careful reconnaissance, labor and time that cannot be taken from the six weeks of active camp are required for this as well as other necessary schemes for the proper carrying out of some of the surveying principles.

Manitowish Waters, Trout Lake in particular, did not lose as many denizens as they might have this past summer. Lack of disciples of Izaak Walton and perhaps of time prevented. A new post-office at Trout Lake with a side line of refreshments will bring home ties a little nearer in the coming years. The main floor in the Dining Hall is now finished, and some rustic furniture has been added so that even there the comforts of home will not be entirely lacking. Whether the new landing pier built by Stride and his gang will remain until next summer is a question. Only submerged rock piles remain of the original crib construction.

The following students attended Summer Camp of 1916:

Andren, O. E., '17.
Chun, Wm. H., '17
Harvey, J. D., '17
Kleinman, H. A., '17
Nusser, Wm. A., '17
Paskill, R., '17
Pedersen, A. A., '17
Shaw, C. L., '17
Smith, E. H., 17
Stride, H W., '17
Tierney, J. W., '17
Walder, H. F., '17
Dierstein, F. C., '17
Nitka, Jesse, '18
Nothhelfer, S. D., '18
Weiss, L., '18
Almuqist, C. G., '19
Chase, D. S., '19
Lake, Ralph, '19
Gold, C. L., '19



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

President..................George M. Fritze
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Secretary....................E. W. Haines
Treasurer..................Harold S. White

On Monday afternoon, September 18, the society held its first meeting of the school year for 1916-1917. This was in the form of a business meeting and the meeting was put through with great enthusiasm.

The following Monday another meeting was held which was well attended both by professors and students. Four students gave a ten minute talk each on a subject of his own choosing. This scheme proved very interesting and it was decided to continue this method of carrying out meetings.

The next meeting, Oct. 18, was in the form of a social meeting. The men of the Junior class were invited to this and on promsie of eats turned out in good numbers. Refreshments were served by the Senior members. The Professors gave the students a few hints about the conduct of the meetings to come.

E. W. Haines.

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Chairman.......................R. H. Earle
Secretary...................H. A. Kleinman
Treasurer......................W. T. Watt

The year started with a smoker held in the Armour Y. M. C. A. rooms on Thursday, October 5, at which about forty men were present. Professor Freeman gave a talk, directed chiefly to men unacquainted with the aims and purposes of the A. I. E. E., pointing out to them the benefits to be derived from active work in the student membership in the A. I. E. E. Stories were told of summer experiences, and after serving refreshments the meeting adjourned.

The second meeting of the year was held Tuesday afternoon, October 24, at 4:30 p. m., in the Physics lecture room, at which time two interesting papers were presented. The first, by Mr. James D. Harvey, Jr., entitled "The Cost of Maintenance of Large Storage Battery Plants," was a very complete discussion of the cost, use and operation of various large storage battery plants. The second paper, presented by Mr. Earl H. Smith, dealt with "Ignition Problems in Modern High-Speed Multi-Cylinder Gas Engines," and told of the attempts made by various manufacturers of ignition apparatus to overcome the ignition troubles in engines of this type.

The meetings held so far this year have been well attended and it is hoped that the interest will continue throughout the year. All Sophomore, Junior and Senior electricals and hydro-electricals are invited to attend, and take active part in these meetings.

H. A. Kleinman.

THE CIVIL ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President. . . . . .A. L. Schreiber
Vice-President. . . . . .L. E. Starkel
Recording Secretary. . . . . .S. N. Miller
Corresponding Secretary. . . . . . . .H. W. Stride
Treasurer. . . . . .C. L. Shaw
Board of Direction
Faculty Member. Asso. Prof. M. B. Wells
Student Member. . . . . . . .S. W. Newman

The first meeting of the society was called to order by the President in the Y. M. C. A. rooms on October 9, 1916. After

a reading of the minutes of the previous meeting, and a most satisfactory report from the treasurer, the president gave a short talk outlining the plans for the year and explaining the purpose of the society for the benefit of the prospective members. Among other things, he stated that there would be a speaker for every one of the twelve meetings, and it is hoped that this will slightly increase the attendance at the meetings; every Senior and Junior should feel it his duty to attend as many of these meetings as possible.

The important business of the evening was the initiation of the candidates for membership, there being eight Juniors present. The initiation consisted of an oral examination in engineering subjects, and though not a difficult one, the candidates displayed a woeful lack of knowledge. Nevertheless, a motion made—in belief that with proper tutelage they would later become a credit to the society—to accept all of the candidates was unanimously carried.

The second meeting was held jointly, on Oct. 24, 1916, with the A. S. M. E. in Science Hall, and was presided over by Mr. A. L. Schreiber. The speaker of the evening, an old Armour man, Wm. Lindbloom, was immediately introduced and a discussion of "Scientific Management" followed. At the close of the discussion, which was heard with close attention by all present, a few questions were asked of, and answered by, the speaker. A vote of thanks was tendered Mr. Lindbloom and the meeting adjourned.

H. W. Stride.

THE CHEMICAL ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

The first meeting of the society was held on Sept. 13, 1916. Mr. A. H. Smith took the chair and called for an election of officers for the coming year. The results of the election were as follows:

President—Mr. A. H. Smith, unanimously elected.

Vice-President—The members of the society were undecided as to whether the vice-president should be picked from the Junior

or Senior class. A motion was made and seconded that the office of vice-president be left open until the next meeting. The motion was carried.

Secretary—Mr. A. G. Fitzner.

Treasurer—Mr. O. L. Hailey.

All members voted in favor of mantaining the dues at fifty cents per semester. The meeting was adjourned with the understanding that the next meeting was to be posted by the president.

A. G. Fitzner.

The second meeting of the society was held October 24, 1916. Prof. McCormack gave a talk on the subject, "What determines the Value of the Engineer to His Employer." Although the subject was delivered to the chemical society in particular, the secretary deems it advisable to give a synopsis of the same on account of its general application to all of the men in the Institute. During the course of his lecture, the professor emphasized the following points:

1. Grades made in college appear to be of secondary importance to the employer. During the experience of Prof. McCormack, he has never been obliged to refer to grades in recommending a man.

2. Integrity in a man is the quality that interests the employer to the greatest extent. The employer wants to feel sure that he can depend upon the employee. He does not want a man who is continually looking at the clock, but one who, in the interest he takes in his subject, forgets the progress of time.

3. The employer wants a man that will follow instructions implicitly. Prof. McCormack emphasized this point by citing several cases where young engineers caused considerable loss to their companies by deviating from the instructions given.

4. Originality. An engineer's ability is measured by his ability to think for himself. If he can do this, he can apply his knowledge in doing old things in new ways, or in developing new processes. This asset is to be supplemented by considerable study after leaving college in order to keep up with the progress in his

field. This is usually accomplished by reading current literature and by attending meetings relating to his profession.

5. Business experience is a valuable asset to the young engineed. Young men leaving college generally lack experience of this kind.

6. If routine work is demanded of a young man, it usually dampens his ambition. This can be avoided by becoming interested in other operations in the plant and determining the relaton of his work to the actual factory operations. In this way he makes himself valuable to his company, thereby increasing his chances of being called upon to perform more important work.

7. He must be able to meet people and get along with them. This is not so often lacking as the above mentioned items.

His talk was very impressive, due to the direct and conservative manner of expression which is always characteristic of Professor McCormack. The topic was well chosen and directly interested every man present.

After the lecture, a business meeting was held. Pres. Smith called for an election of vice-president. The nominees were Cable and Eagle. Cable was elected. The question of a banquet before the Christmas holidays was brought up and tabled until the next meeting. Some discussion was held over the obtaining of outside speakers for the meetings. The meeting was then adjourned. *A. G. Fitzner.*

THE FIRE PROTECTION ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President........................A. Corman.
Vice-President...............H. B. Maguire
Secretary...................H. W. Puschel
Treasurer...................L. W. Mattern

The society has hed two meetings this year. The first—a purely business meeting—was held Oct. 12, at 4:00 p. m., the second—in the form of a smoker—was held Oct. 24, at 8:00 p. m.

At the first meeting various minor details were attended to, and the general standing of the club looked into. It was decided to draft a new constitution.

The second meeting was held in the Y. M. C. A. rooms of the Institute. Those who arrived early engaged themselves in poiltical debates and billiards. When the meeting was formally opened the society had as guests Professor Finnegan, Mr. Allport, and Mr. McDiarmid, one of our alumni. The first business consisted of a lengthy discussion and final adoption of the constitution; and immediately afterwards Professor Finnegan, Mr. Allport and Mr. McDiarmid were unanimously elected honorary members of the society. At the conclusion of the business part of the meeting, the club had the pleasure of listening to a number of short talks by the faculty members and some of the men who had had outside experience.

Mr. Allport presented in a very interesting manner, the benefits that could be derived from the attendance of the meetings of the society. Messrs. McDiarmid and Owen each gave an interesting talk; the former told us what a graduate is likely to run into on his first job, and the latter introduced it to some of the inner workings of an insurance concern. The benefits derived from these talks alone were sufficient to warrant the extra trip to school of all the men present; the information gained from them is valuable in its very practical applications.

After these purely professional talks, Professor Finnegan surprised and pleased the men exceedingly, by a most interesting talk on other than the purely technical side of the engineer's life. Mr. Corman had brought up a number of books on the subect of Fire Protection for the inspection of the men; and it was these books which suggested to Professor Finnegan the ideas for his remarks. He claimed that a man in the course deserved no marked credit for reading these books—rather that it was a duty. We were asked to give especial heed to the so-called cultural subjects. He suggested that we study art and music and other interesting subjects for two reasons; (1) for the pleasure derived therefrom, and (2) because a broad knowledge of such subjects is of great value in the business world; for it is a fact that the

man who can talk intelligently on any subject is much more likely to meet with favor than the man who knows only his particular business. This applies especially to the Fire Protection Engineer in his capacity as an agent for insurance companies; because he will be much more able to meet a man on his own ground—whether it be in regards to a discussion on valves or the latest opera, or a new sprinkler system or "Burns' Ode to Mary."

This gives only the gist of Professor Finnegan's talk; but its true value and the impression it left with the fellows can only be appreciated by those who had the good fortune to be present.

After various discussions on subjects relating to Fire Protection the meeting was closed. Refreshments were served, and then, after the rooms had been sufficiently filled with smoke, everybody went home from the most successful smoker the society has ever had.

We urge that in the future more men take advantage of the meetings—especially the freshmen and sophomores—and the society extends a cordial invitation to all its graduate members to attend the next lecture, the date of which will be announced later.

H. W. Puschel, Sec.

THE ATELIER.

At the first business meeting of the Senior Architectural Class the following officers were elected:

H. G. Ingraham	Massier
K. A. McGrew	Secretary
J. W. Turner	Treasurer
S. V. Williams	Sergeant-at-Arms

These men hold these offices for the entire Atelier as well as for their class.

Practically nothing has been done in a social way due to the rush of work which of late has caused the burning of much midnight oil.

The Sophomore problem, "An End Treatment for the Vestibule of a Museum," which was unfinished last year, has been completed and judged. The following men received mention: First mention: MacEldowney, Wright and Hulbert. Mentions:

Sosna, Pareira, Cowles, Sparling, Kuehen, Bultmon, Koch and Twery.

The last year Freshman problem, "An End Pavilion," has been judged and the following mentions awarded: First mention: Monaco, Cowles, Gaul. Mentions: Ferring, Olekoy, Koch, Schimek and Hulbert.

The following problems have been finished but not judged:

Senior—"A Public Formal Garden."

Junior—"A Dormitory for a Western University."

Sophomore—"An Outdoor Museum of Sculpture."

Freshman—"Composition and Rendering."

Two sketch problems have been completed: "A Small Tomb or Island," "A Large Public Garage." New Senior problem: "An Auditorium for a Technical School."

* * * *

A SELECTED LIST OF BOOKS RECENTLY ADDED TO THE LIBRARY OF THE COLLEGE OF ENGINEERING

Note: This list has been carefully compiled by our librarian, Mrs. Beveridge and her assistant, Mss Broomell. We hope that our readers wll appreciate their efforts by making use of the books which are of interest to them. Especal attention is called to the books on Salesmanship, Accounting and Efficiency, which have been carefully selected by Dean Monin.—The Editors.

AERONAUTICS.

Burls, G. A. Aero engines. 4th ed. Philadelphia, J. B Lippincott Co, 1916

Fage, A. The Aeroplane. Philadelphia, J. B. Lippincott Co., 1915.

Loening, G. C. Military aeroplanes. Jamaica Plains, Mass., Stuertevant Aeroplane Co., 1916.

Talbot, F. A. Aeroplanes and dirigibles of war. Philadelphia, J. B. Lippincott Co., 1915.

CHEMICAL ENGINEERING.

Bacon, R. F. & Hamor, W. A. American petroleum industry. 2 vols. New York, D. Van Nostrand Co., 1916.

Clennell, J. E, The cyanide handbook. 2d ed. New York. McGraw-Hill Book Co., 1915.

Cosgrove, James F. Coal: its economical and smokeless combustion. Philadelphia, Technical Book Publishing Co., 1916.

Cross, C. F. & Bevan, E. J. Researches in cellulose. 3 vols. New York, Lonbmans Green & Co., 1907-1913.

Harbord, F. W. & Hall, J. W. Metallurgy of steel. 2 vol. 5th ed. Philadelphia, J. B Lippincott, 1916.

Howe, H. M. Metallography of steel and cast iron. New York. McGraw-Hill Book Co., 1916.

Koller, Theodore. Utilization of waste products. 2d revised and enlarged English edition. New York, D. Van Nostrand Co., 1915.

Koppe, S. W. Glycerine. Translated from German 2d ed. New York, D. Van Nostrand Co., 1915.

Lunge, George. Coal tar and ammonia. 3 vol. 5th ed. New York, D. Van Nostrand Co., 1916.

Martin, Geoffrey. Chlorine and chlorine products. New York, D. Appleton & Co., 1916.

Martin, Geoffrey & Barbour, William. Industrial nitrogen compounds. New York, D. Appleton & Co., 1915.

Richards, J. W. Metallurgical calculations. 3 vol. New York, McGraw-Hill Book Co, 1906-10.

Sauveur, Albert. Metallography and heat treatment of iron and steel. 2d ed. Cambridge, Sauveur & Boylston, 1916.

Smith, J. Cruikshank. The manufacture of paint. 2d revised and enlarged edition. New York, D. Van Nostrand Co., 1915.

Wagner, F. H. Coal and coke. New York, McGraw-Hill Book Co., 1916.

Williams, Herbert E. Chemistry of cyanogen compounds. Philadelphia, P. Blakiston's Sons & Co., 1915.

CIVIL ENGINEERING.

Agg, T. R. Construction of roads and pavements. New York, McGraw-Hill Book Co., 1916.

Andrews, Ewart S. Strength of materials. New York, D. Van Nostrand Co., 1916.

Etcheverry, B. A. Irrigation practice and engineering. 3 vol. New York, McGraw-Hill Book Co., 1915.

Flinn, A. D., Weston, R. S., & Bogert, C. L. Waterworks handbook. New York, McGraw-Hill Book Co., 1916.

Folwell, A. P. Sewerage. 7th ed. New York, John Wiley & Sons, 1916.

Lyle, William T. Parks and park engineering. New York, John Wiley & Sons, 1916.

Merriman, Mansfield. American civil engineers' pocket book. 3d ed. New York, John Wiley & Sons, 1916.

Popplewell, W. C. Elements of surveying and geodesy. New York, Longmans Green & Co., 1915.

Sellew, William H. Railway maintenance engineering. New York, D. Van Nostrand Co., 1915

Waddell, J. A. L. Bridge engineering. 2 vol. New York, John Wiley & Sons, 1916.

Walker, Frank R. Building estimator's reference biok. Chicago, F. R. Walker, 1915.

ECONOMICS AND PHILOSOPHY.

Burgess, John W. Reconciliation of government with liberty. New York, Charles Scribner's Sons, 1915.

Dewey, John. The philosophy of education. New York, The Macmillan Co., 9116.

Flaccus, Louis William. Artists and thinkers. New York, Longmans Green & Co., 1916.

Kellor, Frances. Straight America. New York, The Macmillan Co., 1916.

ELECTRICAL ENGINEERING.

Berg, Ernst Julius. Electrical engineering. Advanced course. York, McGraw-Hill Book Co., 1916.

Berg, Ernst Julius & Upson, Walter Lyman. Electrical engineering. First course. New York, McGraw-Hill Book Co., 1916.

Coombs, R. D. Pole and tower lines for electric power transmission. New York, McGraw-Hill Book Co., 1916.

Fleming, J. A. Elementary manual of radiotelegraphy and radiotelephony. 3d ed. New York, Longsman Green & Co., 1916.

Lawrence, Ralph R. Principles of alternating current machines. New York, McGraw-Hill Book Co., 1916.

ENGLISH.

Frost, Harwood. Good engineering literature. Chicago, Chicago Book Co., 1911.

Krapp, George Philip. Rise of English literary prose. New York, Oxford University Press, 1915.

Smart, W. K. How to write business letters. Chicago, A. W. Shaw Co., 1916.

FIRE PROTECTION.

Brearley, Harry Chase. History of the National Board of Fire Underwriters. New York, F. A. Stokes Co., 1916.

Dana, Gorham. 1915 and 1916 Supplements to Automatic sprinkler protection. Boston, Thomas Groom & Co., 1916.

Eichel, Otto R. Fire prevention in hospitals. New York, John Wiley & Sons, 1916.

Insurance library association of Boston. Lectures on fire insurance, 1915-1916. Boston, Insurance Library Association, 1916.

HISTORY.

Hayes, Carlton J. H. Political and social history of modern Europe. 2 vol. New York, The Macmillan Co., 1916.

MECHANICAL ENGINEERING.

Eighinger, S. R. & Hutton, M. S. Steam traction engineering. New York, D. Appleton & Co., 1916.

Goldingham, R H. Marine and stationary Diesel engine. New York, Spon & Chamberlain, 1915.

Goodenough, G. A. Properties of steam and ammonia. New York, John Wiley & Sons, 1915.

Henschien, Hans Peter. Packing house and cold storage construction. Chicago, Nickerson & Collins Co., 1915.

Marks, Lionel S. Mechanical engineers' handbook. New York, McGraw-Hill Book Co., 1916.

Nickel, Frank F. Direct-acting steam pumps. New York, Mc-

MODERN LANGUAGES.

Espinosa, A. M. & Allen, C. G. Elementary Spanish grammar. New York, American Book Co., 1915.

Fraser, W. H. & Squair, John. A shorter French course. Boston, D. C. Heath & Co., 1913.

Passy, Paul & Hempl, George. International French-English and English-French dictionary. New York, Hinds Noble & Eldridge, 1904.

PHYSICS.

Bragg, William H. X-rays and crystal structures. London, George Bell & Sons, 1915.

Chamberlin, Thomas Chrowder. The origin of the earth. Chicago, University of Chicago Press, 1916.

Gaster, Leon & Dow, J. S. Modern illuminants and illuminating engineering. London, Whittaker & Co., 1915.

Henderson, Wm. D. Problems in physics. New York, McGraw-Hill Book Co., 1916.

Luckiesh, M. Color and its application. New York, D. Van Nostrand Co., 1915.

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THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.

Edited by the Publication Committee of the Armour Alumni Association.

F. G. Heuchling F. T. Bangs W. H. Lautz

Communications should be addressed to F. T. Bangs, 608 South Dearborn Street, Chicago, Ill.

OFFICERS OF THE ARMOUR ALUMNI ASSOCIATION FOR 1916-17.

R. M. Henderson, '02.................... President
Grover Keeth, '06....................... Vice-President
Walter Reitz, '15 .... Recording Secretary
W. H. Lautz, '13.......... Corresponding Secretary
F. H. Bernhard, '01.......................Treasurer
E. H. Freeman, '02...........Master of Ceremonies

Board of Managers

Retiring in 1917	Retiring in 1918	Retiring in 1919
F. T. Bangs, '13	L. J. Byrne, '04	T. A. Banning, Jr., '07
H. W. Clausen, '04	E. F. Hiller, '06	H. E. Beckman, '09
W. B. Pavey, '99	F. G. Henchling, '17	J. B. Johnson, '12

THE MIDWINTER BANQUET.

In former years the midwinter banquet of the Alumni Association has been held the Saturday before Christmas. But this year advantage will be taken of the by-law passed recently that permits this meeting to be held any time during the month of December. Not by way of diversity but to strengthen the drawing power of the event, several departures from former custom are contemplated. These will be obvious to those who have attended other midwinter meetings.

The latest information received, just as we go to press, is that the meeting will be held Friday, December 15, 6:30 p. m., at the Hotel Morrison, that John W. O'Leary, president of Chicago Association of Commerce, and a former Armour student, will make the principal address, and that the price per plate will be $1.50 or $1.25. Full announcements will be made in notices to be mailed in a few days.

The plans listen very good, and give assurance that the best midwinter meeting ever held, with the greatest attendance, will result. Alumni should watch for the final notice of the meeting and can look forward to a rousing good alumni gathering.

UNITED OR DIVIDED WE STAND?

This fall witnessed the most dramatic national election in the history of this nation, the returns indicating that by the narrow margin of about one-half of one per cent of the total number of voters a President has been elected.

The significance of this figure should strike all thinking men with force. Never in the memory of the men of today's affairs has there been such an urgent need for us to think, not as Armour men, not as engineers or business men, but as citizens of the United States. Not within the memory of an Armour alumnus have there been questions of such vital import to our national integrity as those which confront us today.

Mr. Frank A. Vanderlip, president of the National City Bank of New York, perhaps the most important financial institution in this country, when addressing the convention of the American Bankers' Association, at Kansas City, passed over, almost without comment, the Federal Reserve Act, Rural Credits and the entire range of subjects for whose discussion bankers are supposed to convene, saying:

> "These are a few of the fruitful subjects that might well engage our attention as bankers, but there are times in the world which call men away from their personal and immediate interests. . . . These are not days when we can give our thoughts exclusively to our business, to our immediate affairs. They are days that demand that we think nationally rather than individually or as a business class."

Again he says:

> "If ever a people should pause, therefore, and take stock; if they should look abroad and profit by the experience of others, should comprehend their national dangers in the light of the terrible realities that are being enacted before their eyes in other nations, it is now, and we are that people."

and again:

> "I believe the greatest need of the day—and a need so fundamental as to make other matters inconsequential in

comparison—is the need of universal military, industrial and economical preparedness."

These quotations reflect the profound belief of the best minds in every walk of life throughout the land. We are approaching—no man knows how soon—a crisis in our national life and the part of the engineer in it will be of infinitely greater relative importance than in any previously national crisis this country has known. None will be called on for heavier responsibilities or greater effort or sacrifice than the engineers and it is our present imperative duty to aid in the immediate creation of an irresistible public opinion that will secure these prerequisites to our security and integrity.

The election shows beyond a shadow of a doubt that on November 7 we were not a united people in our conception of national needs. I do not touch upon those matters which are ordinarily of more intimate concern to Armour Alumni because they are completely overshadowed.

R. M. Henderson.

1916 SPRING MEETING.

The annual spring reunion and banquet of the Alumni Association was held Thursday afternoon and evening, May 4, at Armour Institute. It has been the custom in former years to hold this meeting the Saturday preceding graduation, but this year the date was set so that it would occur during Junior Week. This was done to identify the alumni gathering with student activities. The paricular day chosen in the Junior Week calendar was Circus Day, on which the students disport themselves on Ogden Field as clowns and such like to the edification of the assembly. Circus Day has been in vogue at Armour Institute only a few years, and many of the older graduates took advantage of the opportunity of witnessing the frolics of the undergraduates.

The afternoon program was followed by a banquet in the gymnasium, which also was well attended, there being about 150 Armour men present. The principal feature of this meeting was an address by Dean L. C. Monin, who gave one of his customary stirring talks which are always so well received by his former scholars. Master of Ceremonies Benedict called on a number of the alumni for speeches, and among those who re-

sponded were E. C. White, '99; F. G. Heuchling, '07, and H. W. Clausen, '04. The former stated that it was the first time since his graduation that he had been back to the Institue, and expressed himself as being grealy pleased to be at his alma mater and to mingle with his classmates.

A student orchestra furnished music for the occasion, and song sheets were worked overtime between solos and class yells to make the time a gay one.

President Banning called the meeting to order for a business session, and after auctioneering (?) off a number of life memberships in the association the report of the nominating committee was presented. There was no opposition to the slate prestnted, and the following were unanimously elected:

President ....Roy M. Henderson, '02
Vice-President ....Grover Keeth, '06
Recording Secretary ....Walter Reitz, '15
Corresponding Secretary ....William Lautz, '13
Treasurer ....F. H. Bernhard, '01
Master of Ceremonies ....E. H. Freeman, '02
Managers to 1919:—

Thomas A. Banning, Jr., '07;
H. E. Beckman, '09;
J. B. Johnson, '12.

ALUMNI NOTES.

A. D. Quackenbush, '07, has been promoted from assistant superintendent to superintendent of the Mobile Electric Company, Mobile, Ala.

Charles R. Simmons, '15, is employed by the Thomas Molding Brick Company, 1201 Chamber of Commerce Building, Chicago.

C. C. Heritage, '14, is chief chemist for the Chattanooga Chemical Company, Chattanooga, Tenn. This company concentrates sulphuric acid, refines benzol and toulol and manufactures syphetic phenol.

W. F. Sims, '97, who was with the engineering department of the old Chicago Edison Company in 1901, has returned to that company's successor, the Commonwealth-Edison Company. For many years he was connected with the Stone & Webster Engi-

neering corporation and among other important works he was in charge of the electrical installation at the Keokuk plant of the Mississippi River Power Company.

F. M. de Beers, '04, president of the Swenson Evaporator Company, of Chicago, presented a paper at the recent meeting of the American Meat Packers' Association on the subject of "Potash Recovery." Mr. de Beers' firm has installed evaparators for practically all of the companies operating in America and recovering potash in many different ways.

E. F. Nelson, '14, was one of a coachful of employees sent by the Pullman Company to participate in the military training camp at Plattsburg, N. Y. "Nels" came back brimful of patriotism and ideas on the necessity of preparedness, and also exhibited some pride about hob-nobbing with Mayor Mitchell, General Wood, and other notables. Says he feels quite friendly toward the Pullman concern for giving him such a "vacation."

O. F. Abrahamson, '12, who attended the Central Station Institute after his graduation and became an electric power salesman, after spending some time in Bedford and Bloomington, Ind., was promoted to the position of commercial manager of the Interstate Public Service Company, 510 Board of Trade Building, Indianapolis, Ind. "Abe" was back in Chicago during the convention of the National Electric Light Association in May and renewed friendships with some of the Chicago boys.

H. W. Martin, '10, who has been with the Milwaukee Works of the International Harvester Company for the past four years, announces that he has severed connections with that company and gone into business with the Wisconsin Consulting Laboratories of Milwaukee. Like other chemists today, Martin reports that business is very flourishing.

M. V. Stecher, '14, recently joined the regular army and is in signal work. J. F. Hillock, '16, is also in the regular army. Some of our "preparedness" boys.

G. V. Green, '11, has since ApAril been serving as assistant building inspector of Sioux City, Iowa, in addition to his duties as gas inspector.

L. B. Jones, who will be remembered as of '07, reports a very satisfactory business in the manufacture and sale of the "Jones System" electric power plants, which are gasoline-engine plants designed for lighting houses and stores. Whoever sent in the

report forgot to say where Jones is located, but last information gives Kansas City, Mo., as his place of operation.

Here is a good place to hesitate—and after hesitating to offer a reminder of the Alumni Association Banquet, Friday, December 15, 6:30 p. m., at the Morrison Hotel. There'll be some good f's—friends, features and food—so it behooves all good alumni to be there.

Among the chemists present at the National Exhibition of Chemical Industries and the meeting of the American Chemical Society in New York City, were the following Armour men: F. M. de Beers, '04; Harris Perlstein, '14; P. J. Knaus, '13; F. J. Barrows, '10, and G. T. Dougherty, '17.

J. W. Baring and H. N. Simpson, both of '16, are working for the Commonwealth Edison Company, Chicago.

Nine alumni have become life members of the Alumni Association since the last issue of this publication. The new men who never more will be bothered with bills for dues and who will receive all of the benefits of the Association without again "digging down" are: H. R. Badger, '08; C. H. Hammond, '04; H. S. Shimizu, '03; D. A. Whitaker, '12; F. G. Heuchling, '07; W. J. Baer, '10; W. H. Lautz, '13; R. G. Grant, '08; G. H. Patten, '98. The latter two joined the fold as a result of Treasurer Bernhard's campaigning this fall. The number of life members now totals 67.

W. H. Heitner, '11, has resigned as industrial engineer, Chicago Surface Lines. We don't know his new position.

L. L. Edlund, '16, is with Gardner & Lindberg, consulting engineer, Marquette Building, Chicago. He is in good company—meaning F. A. Lindberg, '01, and L. H. Roller, '12.

A. A. Oswald and Henry Bland, both '16 men, have joined forces with the Western Electric Company, New York, N. Y.

Ray S. Huey, '99, superintendent of plant, Universal Portland Cement Company, Duluth, Minn., presented a paper on "The Value of Records to an Operating Engineer" at the annual convention of the Association of Iron and Steel Electrical Engineers at Chicago, September 18-22. He first emphasized the necessity of records to solve cost problems. Local manufacturing conditions make methods of recording data different, so there can be no standard to suit all conditions. To be of great

value records must be accurate and should be automatic in their compilation—a part of the every-day routine of work. Methods of keeping and applying records were described by Mr. Huey, who gave a warning of the danger of keeping too many records. The question to be decided is what records are of enough value so that the information derived will warrant the expense of keeping them. The paper was well received and was commented on very favorably at the convention.

J. E. Saunders, '07, one of the leading lights in the Pittsburgh Alumni Chapter, has been promoted to assistant chief engineer of the Union Switch and Signal Company, Swissvale, Pa.

Roy Grant, '08, who is with the valuation division, Interstate Commerce Commission, is now in Boston, Mass., where a valuation of railroad properties is being made.

H. E. Jedamske, '14, at the present time is at Hatteras, N. C., where he is engaged in work for the United States Coast and Geodetic Survey.

Ralph W. Ermeling, '13, architect, has removed his offices to 1402 Security Building, 189 West Madison Street, Chicago.

William Sieck, '11, is vice-president of the American Oil Products Company, Logansport, Ind.

H. W. Jones, '11, is with the Minneapolis, St. Paul & Sault Ste. Marie Railway Company as assistant engineer. At present he is in charge of the construction of that company's reinforced concrete ore dock at Ashland, Wis.

J. G. Hatman, '10, efficiency engineer for the Semet-Solvay Company, Ensley, Ala., read a paper on "Shop Order and Premium Systems" at the meeting of superintendents of the Solvay Companies at Syracuse, N. Y., in September, and made a short talk on "Premiums in Reducing Accidents" at the fifth annual congress of the National Safety Council at Detroit, Mich., in October.

R. J. Geisler, '12, who has been district manager of the Mathews Gravity Carrier Company, of Ellwood City, Pa., with offices in St. Louis, Mo., has been made manager of the company's office in Cleveland, Ohio. The transfer became effective November 1.

O. R. Prescott, '04, has been in Canal Dover, Ohio, for the past year on the construction of a 600-ton by-products coke oven plant erected for the Dover By-Products Coke Company.

The American Coal & By-Products Coke Company, of Chicago, was the builder and designer of the installation.

J. R. Lauletta, '15, recently accepted a position with the Goldsmith Brothers' Smelting & Refining Company, 5844 Throop Street, Chicago.

E. F. Hiller, '06, who was connected with the production department of Sears, Roebuck & Company for some time, has left that company to become associated with the Blakely Printing Company, 418 South Market Street, Chicago, and says that business is very good.

ADDRESSES.

A revision of the mailing list of graduates of Armour Institute is being made, and correct addresses have not been secured for the graduates listed below. Any one knowing the whereabouts of any of these men will confer a favor on the Alumni Association by informing W. H. Lautz, Corresponding Secretary, care of the Art Institute, Chicago.

G. K. Hanai, E. E.	'99	G. G. Meyer, M. E.	'08
F. W. Twitchell, E. E.	'99	R. D. Morrison, C. E.	'08
R. C. Martin, E. E.	'00	Arnold Pacyna, Ch. E.	'08
W. T. Charles, Ch. E.	'02	F. L. Thomson, Ch. E.	'08
C. T. Brinson, C. E.	'03	J. T. Ahern, F. P. F.	'09
E. L. Quien, Ch. E.	'03	J. E. Megahy, M. E.	'09
H. B. Rawson, E. E.	'03	Arthur Perrine, E. E.	'09
M. J. Knapp, E. E.	'04	F. J. Urson, C. E.	'09
R. E. Williams, E. E.	'04	F. O. Godfrey, E. E.	'10
H. J. Ash, E. E.	'05	T. G. von Gunten, Arch.	'10
B. E. Beamer, E. E.	'05	W. K. Howenstein, Arch.	'10
G. W. Fiske, M. E.	'05	E. M. Ruede, E. E.	'10
Edward McBurney, Jr.	'05	L. T. Zeisler, E. E.	'10
E. W. Cutler, E. E.	'06	C. E. Beck, M. E.	'11
N. L. Edson, M. E.	'06	B. Greengard, Arch.	'11
Philip Harrington, E. E.	'06	F. H. Griffiths, M. E.	'11
E. D. Meyer, E. E.	'06	W. G. Tellin, E. E.	'11
F. T. Pierce, M. E.	'06	F. G. Hazen, E. E.	'12
J. N. Schumacher, Ch. E.	'06	M. Malzen, M. E.	'12
A. W. Tyler, E. E.	'06	H. T. Yoshida, M. E.	'12
G. S. Laubach, C. E.	'07	C. J. Furay, Arch.	'13
David Lurvey, M. E.	'07	J. H. Hibler, Ind. Arts	'13
C. S. Millard, M. E.	'07	Charles Kopald, E. E.	'13
C. J. Nelson, M. E.	'07	C. D. Lundblad, Arch.	'13
E. A. Pratt, M. EE.	'07	L. M. Jensen, Arch.	'14
W. H. Reker, E. E.	'07	C. G. Schmidt, Arch.	'14
Walter Sanders, E. E.	'07	R. T. Evans, M. E.	'15
Gustav Stanton, M. E.	'07	T. K. Mieczkowski, E. E.	'15
G. D. Tompkins, C. E.	'07	F. E. Price, Ind. Arts	'15
F. C. Collins, E. E.	'08	E. T. Taylor, Ind. Arts	'15
V. E. Lawrence, E. E.	'08	E. S. Youngberg, Ind. Arts.	'15

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THE APPLICATION OF SCIENTIFIC MANAGEMENT TO THE PROBLEMS OF THE FACTORY.

BY CARLE M. BIGELOW, INDUSTRIAL ENGINEER, COOLEY & MARVIN CO., BOSTON, MASS.

I shall endeavor to show how Scientific Management attempts to satisfy the age-old demand for more equable conditions of life by the satisfaction of the problems of the modern factory, since these problems are the obstacles to modern man's satisfaction of his demand for more equable conditions of life. The application of Scientific Management to the great problems of the factory will first be considered, and then a detailed account given of the technique of the practice of Scientific Management. The specific application of Scientific Management to the problems of the factory is as follows:

First: The necessity for proper mathematical combination of the several units or processes, which, when properly combined, gives continuously balanced production. Scientific Management endeavors to reduce each operation to a science, utilizing all available experience and by constructive evolution, substitute rule of thumb methods with others founded upon actual knowledge. The carrying out of such study enables the various units or departments of a factory to be so reorganized that the usual over or under production of the individual units is avoided, resulting in a constant uniform production.

Second: The necessity of providing for constant progress without sacrificing the efficiency of management. The very formation of Scientific Management itself, consisting in its application by a corps of experts who assume the entire responsibility for the reorganization, solves the problem of progression without endangering the efficiency of the regular management. Scientific Management provides by the formation of either the so-called staff or functional forms of organization in addition to the line organization, a permanent means for the continuance of such progression after the withdrawal of the experts, it being

carried on by the staff or by the functional foreman as the case may be.

Third: The submergence of the individual and the entailed danger of loss of self-incentive. In the formation of management under scientific methods, the responsibility is evenly divided between the workmen and the management, not in the old manner of the division of supervision and performance, but in co-ordination, or side by side labor by the two. This gives to the workmen the same dignity of performance as to the management. Instead of performing duties as arbitrarily dictated by his employer, the workman labors together with his employer for a common mutual purpose, each within his own sphere and with the sense of individual responsibility. Since reward is made proportional to result accomplished, self-incentive is fostered rather than submerged.

Fourth: The tendency towards a military system of management, with resulting ineffectual control. The division of responsibility between workmen and management, and the creation of the progressive organization both mitigate, especially the former, against the military form of organization, with responsibility passed down and on from manager to superintendent, to foreman, to assistant, to laborer, wherein responsibility is divided and initiative restricted. Responsibility is absolutely fixed under Scientific Management.

Fifth: The absolute lack of standardization. The creation of a science for each process of an industry creates standards of these units, which, when combined, give a standard of the industry. As stated above, these standards are originated from all possible available experience and composed as well of the results of constructive evolution. Thus an industry under Scientific Management becomes a set of standards rather than a mass of incoherent, often faulty, processes and ideas.

Sixth: The question of proper division of earnings into manufacturer's profit and workmen's wages. Earnings and profits are changed under scientific management from arbitrarily set wages and chance resultant profits, into earnings proportionate to effort, and profits into a definite legitimate percentage. The earnings of the workmen are regulated by wage payment methods based upon scientific time-study. In other words, upon absolute facts, not arbitrary standards or guesswork. The manufac-

turer's profit is maintained by a cost system whereby he is enabled to set his selling price so as to maintain a definite standard of percentage of profit above actual cost. Instead of the old haphazard method of workmen being paid as little as they would accept and the employer seizing all the profit possible, under Scientific Management, the workman receives a legitimate remuneration proportionate to his effort, and the manufacturer a percentage of profit equivalent to a legitimate return on his investment. In fact, the very object of management based upon scientific principles is to secure the maximum prosperity for the employer, coupled with the maximum prosperity for each employee. In summation, Scientific Management is based upon the principle that prosperity for employer or employee only cannot exist; prosperity is not individual, but mutual; both must possess it, or neither.

SCIENTIFIC MANAGEMENT.

Scientific Management is doubtless our newest science as the first actual work along these lines was not started until Frederick W. Taylor began his famous experiments, the result of which are outlined in his "Art of Cutting Metals." To be sure, Adam Smith in his "Wealth of Nations" in 1776, outlined some of the conditions of industrial control which Scientific Management hopes to bring about, as follows: "This great increase in quantity of work which in consequence of the divison of labor, the same number of people are capable of performing, is owing to three different circumstances; First, to the increase of dexterity in every particular workman; Second, to the saving of time which is commonly lost in passing from one species of work to another; and lastly, to the invention of a great number of machines which facilitate and abridge labor and enable one man to do the work of many." Furthermore, Chas. Babbage in 1832, made the first analytical analysis of manufacture. A significant quotation from his work is as follows: "That the master manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill and force, can purchase exactly that precise quantity of both which is necessary for each process; whereas, if the whole work were executed by one workman, that person must possess sufficient skill to perform the most difficult, and sufficient strength to execute the most laborious, of the operations into which the art is divided."

In all the literature published up to our time, these two authors are the only ones who even anticipated any of the principles of Scientific Management. Both of these authors were theorists, neither of them carrying out any industrial experiments or improvements. Therefore, to F. W. Taylor must be given the credit as the father of the new science, but if this credit for being first in the field was not his, he could still be called the father of science as his work was something that has never been duplicated, and probably never will be. His experiments, investigating, or rather creating a science of the cutting of metal, were extended over twenty-six years, cost $200,000.00, and from 800,-000 to 1,000,000 pounds of metal were cut into chips. From these experiments, twelve variables were isolated and studied; and finally an equation worked out solving the problem. But this experiment was but a small part of his work. While this was going on, he evolved a system of management which is the foundation of our science.

Probably the best definition of Scientific Management will be a brief outline of the four fundamental principles which Mr. Taylor isolated:

First: The reduction of each operation to a true science.

Second: Scientific selection of men, material and machines.

Third: Scientific teaching of the men.

Fourth: Division of responsibilty between management and operatives.

It has become the fashion to write about the technique of Scientific Management rather than its fundamental principles or theory. A very clever demarcation between Scientific Management and its application, is found in the records of the Dartmouth Conference on Scientific Management. During the discussion of the application of Scientific Management to machine manufacture a gentleman asked Mr. Carl Barth, who had charge of that particular section, the following question: "How much is bonus payment a part of Scientific Management?" Mr. Barth replied: "It does not belong necessarily to it. There is not a single detail we practice which is a necessary element of Scientific Management. Scientific Management means certain principles and the vehicle of those principles can be almost anything. I am constantly modifying the details of the system; the trouble with all systems of paying a man is, you haven't attempted to get at how long it takes to do the job."

This brings up the point that "systematized" or any definite form of more efficient management is not necessarily Scientific Management.

From the Scientific Manager's standpoint, all industries divide themselves into three groups: Unsystematized; Systematized; and Scientific. There is a great deal of popular confusion between Systematic and Scientific Management, and a large part of the work of so-called "Efficiency Engineer" today is Systematic, not Scientific. It is the aim of this paper to treat of Scientific Management, not Systematic. As stated above, Scientific Management objectifies the plant or operation in question, experimenting, studying and evolving it in the same manner that a chemist would an unknown substance. Scientific Management does not, like Systematic Management, endeavor to apply certain fixed practices, but takes each case under consideration separately, studying it with certain fundamental principles always in mind. Undoubtedly, the very basial principle of the science and its application is best expressed in some quotations from the works of F. W. Taylor. He says: "The principal object of management should be to secure maximum prosperity for the employer, coupled with the maximum prosperity for each employee." "Scientific Management has for its very foundation, the firm conviction that the true interest of the two are one and the same; that prosperity for the employer cannot exist thru a long term of years unless it is accompanied by prosperity for the employer and vice versa; and that it is possible to give the workman what he most wants—high wages—and the employer what he wants—a low labor cost—for his manufactures." "The greatest prosperity can exist only as the result of the greatest productivity of the men and the machines, i. e., each man and each machine turning out the largest possible output."

Fundamentally, Scientific Management's very basis is increased productivity to the mutual benefit of employer and employee. Prosperity means more equable conditions of life, thus the assertion that Scientific Management is a distinct and direct answer to an industrial demand which has been constant and vital for ages.

Scientific management began with the work of F. W. Taylor and has been developed by the men associated with him, and those who have become associated with these latter. Although

there are a comparatively large number of practising industrial engineers today, many of whom have been very successful and original, there has never yet been another who has seen the clear flame of the philosophy of Scientific Management so distinctly as Mr. Taylor. The Science is too young to outline any history of its development. The first marked step after its conception by Mr. Taylor, was probably the conference held at Dartmouth college, October 12th, 13th and 14th, 1911, devoted to addresses and discussions regarding Scientific Management. At this conference Mr. Taylor and several other eminent exponents of the science were present and great stimulus was given to industrial organization by means of these meetings.

The aims of Scientific Management may be classified in five steps:

First: The reduction of industrial processes to units and these units subjected to scientific observation and experiment, including time study.

Second: The setting of a task or standard time for the performance of every operation.

Third: The scientific training of the workmen to achieve the standard.

Fourth: The division of responsibility between management and workmen, the workmen being allowed to utilize their full energy in performing the operations.

Fifth: The inspiration of the workmen to perform their tasks by the means of a bonus payment plan.

A good outline of the science is given in the majority report of the sub-committee of administration of the "American Society of Mechanical Engineers" for 1912, which outlines the regulative principles of management along scientific lines to include four important elements:

A. Planning of the processes and operations in detail by a special department organized for this purpose.

B. Functional organization by which each man superintending the workmen is responsible for a single line of effort. This is distinctly opposed to the older type of military organization, where every man in the management is given a combination of executive, legislative and judicial functions.

C. Training the worker so as to require him to do each job in what has been found to be the best method of operation.

D. Equable payment of the workers based on quantity and quality of output of each individual. This involves scientific analysis of each operation to determine the proper time that should be required for its accomplishment and also high payment for the worker who obtains the object sought."

In other words, the aim of Scientific Management is to reduce business to an absolute science. Vast sums of money are spent on educational institutions in which it is insisted that the different sciences be carefully and thoroughly taught. No intelligent person would for a moment believe that a science such as chemistry could exist or be useful without its fundamental rules and principles. One would not think of hiring a chemist to follow out any general ideas regarding his work which might appeal to him feasible; the basis of his work is required to be actual, exact knowledge of his science and all his theories and practice must be based upon these fundamental principles. In business, however, in the industrial world, that phase of activity which willingly supplies the capital for the development of the precise sciences and which employs them in the evolution of various technical problems, is found an absolutely different line of reasoning. In the handling of the industries themselves, every manager assumes his particular business to a rule unto itself without fundamental law or principle. You can enter a hundred factories manufacturing the same product and in few cases will you find similar methods being used. Scientific Management endeavors to establish fundamental laws, the observance of which are just as essential to the successful operation of industry as are the fundamental laws of chemistry to the application of that science. It maintains that there is only one best way to accomplish a certain purpose under similar conditions and that the application of its principles to any business will give as a result, a specific, definite line of procedure for the economic conduct of that business.

In outlining the general methods pursued in the installation of scientific management, the discussion will be grouped in four divisions, each division applicable to one of the four fundamental principles.

Division 1. *Reducing to a science.*
1. Analysis of processes.
2. Common sense as well as technical analysis.
3. Motion study.
4. Time study.
5. Standardization.
6. Symbolization.

Division 2. *Scientific selection of workmen, materials and machines.*
1. Scientific selection and handling of labor.
2. Common sense as well as technical analysis.
3. Types; speeds; belting and upkeep of machines.

Division 3. *Teaching the workmen*:
1. Functional foremenship.
2. Standard instructions.
3. Task.
4. Bonus for success (Wage payment methods).

Division 4. *Division of responsibility between management and workmen*:
1. Planning department.
   a. Scheduling.
   b. Materials control.
   c. Production control.
   d. Timekeeping and cost control.
   e. Efficiency control.

ANALYSIS OF PROCESSES:

It is a surprising fact that in the large majority of businesses, that no person or group of persons has a complete knowledge of the actual operation of the business, nor rarely are there records of the same, even of the most incomplete character. In the application of Scientific Management, the point which must be kept constantly in mind, is the insistance upon obtaining facts, not guesses, regarding all phases of the work at hand. Therefore, the first step in the work is to obtain a definite and complete record of the product and all operations involved in the complete process of the manufacture of this product. Some of the principal topics for investigation are:

1. The product. A complete classification of the various types and groups of articles to be produced.
2. The fundamental nature of the individual operations.

3. Their sequence, distance traveled and devices used for handling the product.
4. Machines and materials involved.
5. Number and type of operatives utilized for each operation.
6. Wages paid for each operation.

During the study of these processes, the various faulty and weak points will be generally noted; in other words, this investigation phase compares to the chemist's analysis of the unknown substance. Just as he studies the properties, relations, and component parts of the substances, so does the engineer during the analysis of a factory or business, objectify and study all phases of his proposition. After this general analysis, he begins his study along specific lines by concentration on individual operations. The resulting information should be carefully noted and tabulated for future use.

ROUTING.

Before a great deal of efficient reorganization can be accomplished, the subject of routing must be taken up very carefully. Briefly stated, "Routing" means the laying out of the shortest possible routes of travel for the various types of product through their intermediate operations to completion outlining the necessary re-arrangement, additions, alterations, etc., to buildings, machinery and equipment. The final result of routing is the physical reorganization of the plant and equipment. The usual procedure is to first make what is known as a "Schedule of Routing" from information obtained from the management, foremen, any available records, and finally, from personal observation. The first step in the evolution of this schedule is the classification of this product wherever possible, into groups. Then the operations involved in the manufacture of each group should be tabulated, showing the proper sequence. The amount of each group manufactured during a definite period should also be obtained. These component groups of information should all be combined upon one large sheet. It will then be found that a complete list of all operations can be easily tabulated. It will next be noted that the sequence of operations for various groups will differ. Where this occurs, the process of manufacture for the groups differing should be carefully studied to determine whether these differences cannot be eliminated and the pro-

cess standardized. Should question arise as to which method should be given preference, efficiency (cost-time-effort) being equal, the relative proportion of the two groups manufactured should be referred to, and the process adopted which is already in use for the larger of the two.. The value of this is to eliminate changes involving large percentages of product whenever possible. Study of this nature will soon reduce the schedule to a point where the various operations for all groups will have a similar sequence with a few exceptions. Should the proportions of product be very small, these exceptions can be ignored, but if they are large, operations should be subdivided, inserting the portions of the sub-divided operation in various places in the schedule in order to rectify the exceptions. The schedule will then give an absolutely progressive sequence of operations, from which the routing may be evolved.

Scaled floor plans of the various departments are obtained, showing the location of all machines, equipment and supplying devices. These should be carefully studied with reference to the Schedule of Routing, and a tentative plan evolved for rearranging the equipment to meet the sequence of operations shown by the schedule, bearing in mind that the proposed route of travel must be ultimately the shortest possible distance, with absolutely no retracing or crossing the routes of travel of other portions of the product. As soon as a tentative plan is evolved, blank floor plans of the various buildings should be made to a definite scale, and blocks and strips of cardboard cut out on the same scale representing the exact size and shape of each machine and piece of equipment. Machines should be indicated by name and by number if any system of machine numbering exists. The direction of travel of product through each machine should be indicated by an arrow of one color and the direction of application of the drive by another color. Shafting and other equipment, such as elevators, etc., which should not be moved if possible, may be drawn into the floor plans with pencil. This equipment of scaled floor plans and cutouts of equipment are known as templets. The problem now becomes a sort of chess problem. The engineer places his cardboard cutouts on the floor plans, moving them about, studying the relation of one to another with the ultimate idea in mind of so locating all machines and equipment that his product will travel in the above mentioned

direct line. The scaled cutouts may be temporarily fastened in place by the means of thumb tacks.

In this arrangement of machinery, the connections with piping, shafting or other power application, must be considered. Also the best position for the operatives in relation to the machines must be taken into consideration and the effect of these positions upon illumination. The machines should be grouped so that they will fall into natural divisions over which sub-foremen will have charge. Sufficient space must be provided for aisles and passageways. Wherever posisble the passageways should be used for work traveling in one direction only. Where a main alley occurs through which traffic will travel in both directions, the side to be used (right hand whenever possible) for each direction should be indicated. In laying out the passageways, the method of handling the materials must be carefully considered. Wherever possible, conveyors or chutes should be used for transportation. A marked saving in the operation of these conveyors is made possible by the use of gravity devices wherever feasible. There is practically no problem of transportation which cannot be solved by one of the many types of conveying devices now on the market. In all cases, however, they are not feasible from an economic standpoint. For instance, at times material must be in a certain order for supply to a succeeding operation; in such case, it is possible to build a type of receiving truck which will receive the product in such form and order that it may be correctly fed into the next machine, a more economic procedure than the use of a conveyor. Also, there are times when the location of conveying devices would interfere with the routing of other forms of the product and, of course, there are some instances where the cost of surmounting the mechanical problem is too great for consideration.

When the routing has been set up on the templets it should be submitted to the management for their approval and suggestions. No matter how careful the study of the various processes may be by the engineer, some details are bound to escape him which can be caught at this time by the management. When the physical or mechanical arrangement has been approved, the economic value may be demonstrated as follows: Select a few representative examples or groups, utilizing the majority of the equipment. On a set of blank scaled floor plans showing the

present arrangement of equipment outline the routes of travel of these groups by means of colored lines. Measure the final result in inches and convert into feet travelled by means of the scale. In a similar manner demonstrate the routing of these same examples or groups on another set of charts upon which the proposed arrangement of equipment is drawn and calculate the result in feet travelled, the same as above. The most adaptable form for obtaining these charts is to have tracings made from the original floor plans and from the templet drawings, and have black and white prints made from the tracings. Comparative legends may now be set up on both proposed and original sets of charts showing a direct comparison of the feet traveled according to the present and proposed routing for each group.

A factor which has worked out in several applications of routing, but which is simply an approximate, not a precise exact factor for determining the saving in dollars and cents, is as follows: Determine the number of feet saved for each example plotted; determine the percentage that this saving is of the corresponding original routing; multiply the per cent saved for each example by the number of units produced in a definite period; add these products and divide by the total units of all these examples made in the period. This will give the percentage of distance saved on the entire product. Divide this percentage by two and find this per cent of the total direct labor of the plant for a year, and you have an estimate of the labor reduction which will be made possible by the installing of the proposed routing. The author has worked this factor out in three instances, all in different industries, and found that it checks very well with the actual saving. In some industries peculiar conditions might arise which would make it unreliable, but by bearing in mind that this is merely an estimation, it will be found useful in estimating the possible saving by re-routing.

MOTION STUDY.

Authorities vary in their recommendations regarding motion and time study. Some with great success make time study upon the operations as they find them, noting the unnecessary motions and the time required, and form new rates by the elimination of the unnecessary times. Such study is generally a combination of motion and time study. The author recommends, however, the use of motion study by means of which the opera-

tion is perfected, and instruction of the operator in this improved method before the time study is made. Therefore motion study will be described as a preliminary analytical operation, taking place before actual time study is made.

The first principle of motion study is the geometrical axiom that a straight line is the shortest distance between two points. This is an example where pure science can be applied correctly to the formation of industrial procedure. No matter how skillful a traditional operative may be, hardly an instance can be found where unnecessary motions are not used, where motions are in proper sequence, or where the existing motions can not be shortened. The first step in motion study is to study the method of supply. In other words, is the material which the operative is to handle coming to him in the best possible manner? Is it so delivered that he does not have to handle or arrange it before he begins the actual accomplishment of his operation? Supply methods must be absolutely perfected before the actual motion study begins. This may necesistate, of course, some preliminary observation as to the operation in order that the observer may determine the best manner in which the material should be supplied. After the material is being properly supplied, the observer should classify each motion of the operation; he should study each one, noting particularly the following points: Is each motion necessary? If eliminated, will it add to any other motion? If so, is this increase shorter than the motion eliminated? Is each motion accomplished in as direct a manner as possible; in other words, in a straight line? Can motions be substituted which, while longer, will incur less fatigue and hence be quicker? Should any motions be added or substituted which will improve the efficiency of the operation? Are any motions used which incur an unnatural position of the body such as stooping or lifting above the shoulders, which subject the operative to unnecessary fatigue? Can conditions be changed to eliminate such unnatural conditions? Can changes in motion be made to improve quality?

In connection with this study the arrangement and utility of equipment and machinery will of necessity be noted. Often simple changes in the machine will eliminate or shorten motions and very often superior equipment can be recommended, as for instance, power screw drivers in place of hand braces for furni-

ture driving up. After the design of the machine and equipment have been improved so far as possible, the last function of the observer who has made the motion study, before starting the time study, should be to raise the speed of the machine to the highest possible point, bearing in mind, safe mechanical capacity of the equipment, safety of the operative, depreciation of the quality of the operation. When all of these things have been accomplished, the observer should write a report noting the original condition of the operation and his proposed method in detail, including in the report a discussion of improvements to machinery and equipment, and a recommendation of the general type of operative required.

TIME STUDY.

By the motion study, the observer has created a standard of operation. It now remains for him to determine the factor of time. Before this can be done, certain conditions must be brought about; the operative must be taught the standardized operation and as noted above, supply in the proper manner guaranteed, the equipment and machinery used located in the best possible positions and operated at the greatest possible safe capacity. Furthermore, general conditions such as temperature, light and cleanliness should be made as salutary as possible. It is an absolute fact, undisputed by any experienced time study man, that a good time study cannot be made with the operative in a cluttered unsanitary surrounding, and this point should be borne in mind by managers at all times, for after the operations are standardized, the workmen cannot maintain the standard pace unless these conditions are also maintained. The operator himself, should also be the best obtainable. By 'the best obtainable," is not meant an extraordinary operative, but a high type, earnest, intelligent, conscientious workman. As a standard of efficiency is to be set, this standard must be set with best obtainable material, and just as it was necessary to provide the best conditions as to machinery and equipment, the same should be required as regards the operative.

The next condition to bring about is the proper mental condition of the operative under observation. The procedure to be undertaken should be carefully explained to him and his cooperation obtained. It should be demonstrated to his absolute satisfaction that everything is square and above board, and that

all deceit and ignorance are to be done away with, and that the observer's purpose is to set a true, accurate and legitimate rate which will not over-tax the strength or ability of the operative in any manner, and that the same attitude is expected from him; that no soldiering or deviation from the standard motions will be tolerated, that he must play as fair and square as the observer intends to himself.

The actual time study then begins. A printed form is used having spaces for the recordance of the time noted for each motion, corresponding spaces for the noting of the actual times taken for each motion, found by subtracting each time noted from the succeeding one. When the time study begins, the stop watch should not be stopped until observation ceases for some reason; the watch should run through all delays, the reasons for the same being carefully noted. The divisions of the observation should be made as near as possible to the standard motions, but some of these may be either too long or too short for correct observation. In general, the author has found that .03 of a minute is about the smallest time which can be read accurately, and the largest divison noted should not exceed .10 of a minute if possible. Thus some subdivision or combination of motions may be necessary. The watch is read at some point in each motion, generally at the completion. Whenever possible, some sound connected with each motion should be used as the observation point. For instance, should a motion be the use of a pair of shears, the click of the instrument as the cut is made should be the signal for the reading of the watch. A little practice and the observer will soon find that he can note the operation, read the watch and make the notation on his sheet almost subconsciously. Time study should be continued at intervals until several hundred observations of each motion have been obtained in many instances, although in some simple operations with a well trained operative, a few dozen may suffice. The judgment of the observer will have to be used in this matter, his basis being the number of readings of nearly similar time he obtains. Should his readings scatter widely a large number of observations will be necessary, but if they fall within a comparatively narrow margin of time, fewer observations will be necessary.

Having completed the observation, he should enter in spaces

which should be provided on the back of the time study sheet, the number of times each operation has occurred in each of the various observed times. He next strikes out all readings which are unquestionably inaccurate, either through faulty reading or caused by delays which he has noted, and notes the minimum time taken for each operation. This, however, is not the actual time to be taken in creating his task. There are many theories for selecting the proper time for each motion. A method which the author has used with success, is to take a time which is half way between the average of all legitimate observations and the minimum observation for that motion. These selected times for the individual motions are then combined according to an equation which conforms to the relation of the individual motions to the total operation. For instance, should one motion occur twice, the time allowed for this part of the operation will be two times the observed time, etc. Next the factor of rest and fatigue should be considered. If the operation is extremely arduous, subjecting the operative to extreme temperatures or disagreeable odors, or some other unsatisfactory conditions which cannot be eliminated, a large percentage should be allowed for rest and delays. Occasionally this will be as high as 50 per cent. In general, however, 10 per cent to 25 per cent should be added to the actual theoretical time for rest and necessary delays. In some operations, it may be advisable to utilize definite rest periods in place of the above allowances. When the operation is fatiguing or tiresome enough to necessitate this, such periods should be definitely specified and provision made for insisting upon their observation. The necessity for this allowance for rest to counteract fatigue has been demonstrated by Mr. Taylor in his study of fatigue. He proved that there is a scientific relation betwen work performed and the energy required, hence, the maximum efficiency cannot be obtained without maintaining the proper relation between the two. The value of motion and time study is best demonstrated by the following quotation from F. W. Taylor: "That there is a difference between the average and the first-class man is known to all employers, but that the first-class man can do in most cases from two to four times as much as is done by an average man, is known to but few, and is fully realized only by those who have made a thorough and scientific study of the possibilities of men. First-class men are not only

willing but glad to work at their maximum speed, providing they are paid from 30 to 100% more than the average of their trade."

STANDARDIZATION.

The study of the routing and the results of motion and time study form the basis for the standardization of the entire operation of the plant. In the first section of this division, the analysis of the original processes which must first be made was outlined. After re-routing, motion and time study, the synthesis of the processes may be carried out. Positive fact is now available for the majority of details. These facts should be carefully compared with the results of the prelimnary analysis and a standard procedure determined and recorded for every detail of the business. This standardization will, of course, involve still further study along many lines. It is, in fact, the actual completion of the investigation, studying all details which have not been handled in the previous study. General methods of delivery and supply of material, and lapses between operations or series of operations of manufacture, which have not been covered by the routing, should be studied at this point. Schedules for the systematic inspection of machinery and equipment to prevent breakdowns should be orignated. Inspection methods should also be drawn up in order to automatically maintain the quality of product. Motor and belt inspection should be provided to insure complete utilization and economy of power. Forms for all necessary records should also be standardized. The effect of the new methods upon the selling and financial sides of the business must also be considered. In general, this is the time for the elimination of the few remaining traditional ideas, and the reduction of these to facts definitely recorded. This point of progress should not be left until a definite standard has been guaranteed for every phase and detail of the industry.

SYMBOLIZATION.

In direct connection with standardization, and essential to it, is symbolization. In recording the standards it is necessary to have some progressive means of nomenclature for all series of facts. For instance, the various departments of the plant must be given symbols which will be significant and by which they may be definitely known; next the machinery must be given a

series of denoting letters and numbers which will suggest the relation of the machinery to the various operations or classes of product, upon which they are used. In fact, the various units and groups of the product itself should be given symbols for their notation. Operations, supplies, rates of payment, instructions and all such facts must have their particular set of symbols in order that the records may be made intelligently and easily comprehended. In making out these symbols, they should be made with the sole idea of being simple and as suggestive of the article or operation symbolized, as possible. Intelligent symbolization is absolutely essential to proper standardization. Furthermore, the various sets of symbols should have a common base, in order that the connection between different standards may be readily grasped. Filing of records is wonderfully simplified by adequate symbolization.

(To be concluded in the March issue.)

The great opportunity for the engineer of the future is in the direction and mangement of our various manufacturing industries. We are about to become the world's workshop, and as competition grows sharper and as greater economies become necessary, the technically trained man will become an absolute necessity in the leading positions in all our industrial works.

—Johnson.

DESIGN, CONSTRUCTION AND CALIBRATION OF APPARATUS PROPOSED FOR ADVANCED IMPROVEMENTS IN THERMAL CONDUCTIVITY TESTS.

BY BRADLEY SAYRE CARR.

The purpose of this investigation has been to develop a device which will measure thermal conductivity accurately and be free from the objections associated with past practice. Inasmuch as the whole accuracy of making tests depends upon an accurate measurement of heat the electrical method has been decided upon. Since electrical energy can be measured with a high order of accuracy it follows that the heat equivalent of that energy can be determined with the same precision; furthermore the rate of heat generation is under instant and accurate control, an extremely important consideration of this kind.

The General Problem.

This method consists of an electrically heated plate which is placed between two sheets of the material to be tested, and outside of these sheets are placed two hollow flat plates cooled by circulation of water. With a certain center area of the test specimen, the heat lost from the electrically heated plate goes through the specimen into the water-cooled plates. This heat is measured from the electric input. Thermal junctions are used to measure the temperature difference between the hot plate and the cold plates. Knowing these factors, the area and thicknese, the thermal conductivity of the material under test may be calculated.

The liability to loss from the edges is accounted for as explained in the design of apparatus.

Design and Construction of Apparatus.

Hot Plate:—The heating coil consists of 50 turns of Nichrome resistance ribbon .25″ wide and .01″ thick, wound so as to be evenly spaced on a slate core, 18″ square and 3/8″ thick. This gives a uniform generation of heat to each square unit of plate area. Covering the windings of the Nichrome ribbon are

*Class of 1916.

two sheets of mica bond, each .03" thick. Next to the mica insulation are placed copper plates 1/8" thick. Figure 1 of hot plate shows the details of construction as outlined above.

In order to reduce the effect of the loss of heat from the edge of the hot plate, each copper cover plate is divided so as to confine the test area to an inner portion 9"x9", and an outer guard

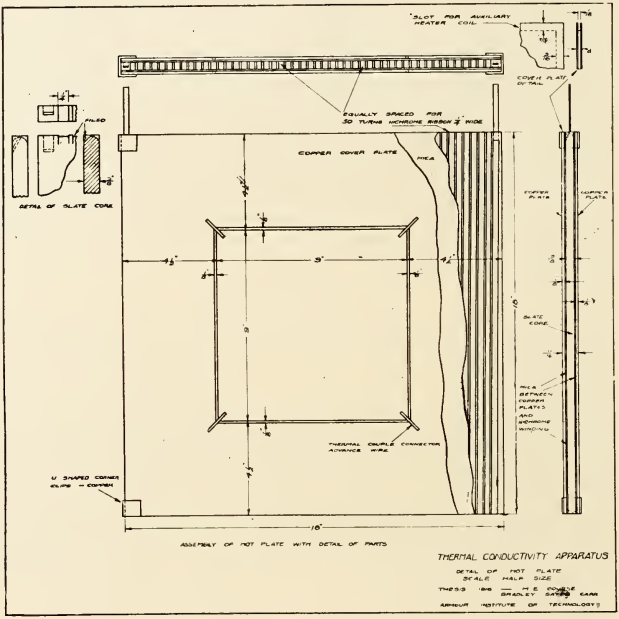

Fig. 1. Detail of Hot Plate.

ring. An 1/8" air space is left between the two parts, the latter being joined at the four corners by thermal couple connectors of Advance wire. This method of construction reduces to a minimum the flow of heat from the inner test square to the outer guard ring. The thermal couple connections are the means of measuring temperature differences between the two parts of the copper plates. Any temperature difference by the lateral escape of heat is compensated for by an auxiliary heater consisting of

three turns of No. 26 Advance wire wound in a groove cut in the edge of each copper cover plate. By maintaining the test square area and that of the guard ring at the same temperature a sufficiently large area of the test specimen is heated to a uniform temperature.

Four copper clips of U shape clamp the five ply construction together. The various thermal couple junctions attached to this plate are explained in the description of the wiring diagram. The

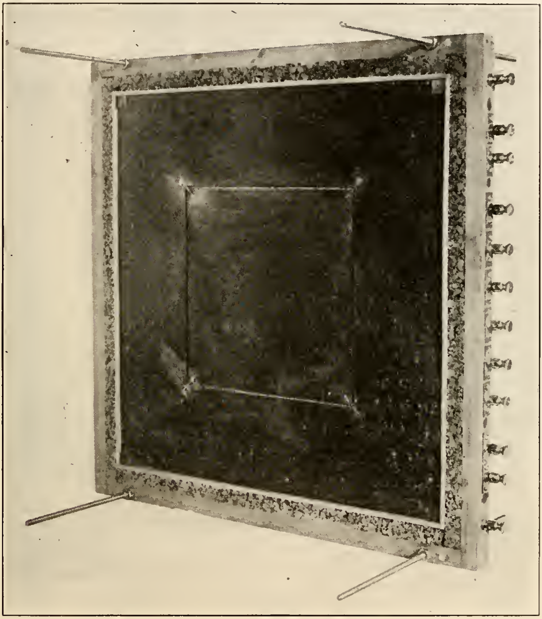

Fig. 2. Hot Plate.

plate is mounted in a wood frame which is cork lined. Narrow wood cleats hold the plate to the frame. All wiring leads are connected to binding posts, attached to the front edge of frame. Figure 2 shows the finished hot plate ready for use.

Cold Plates:—There are two of these plates, one to be used on the left hand side of the hot plate, and the other, the right hand plate, used on the corresponding side of the hot plate. These plates are designed to handle cooling water and to distribute the same over the test surfaces at uniform rates of flow.

Each plate consists of an aluminum grid which has twenty-three cored slots evenly spaced on the plate face. The inlet manifold is at the bottom and the discharge at the top. A copper cover plate ⅛" thick is fastened to the grid with countersunk

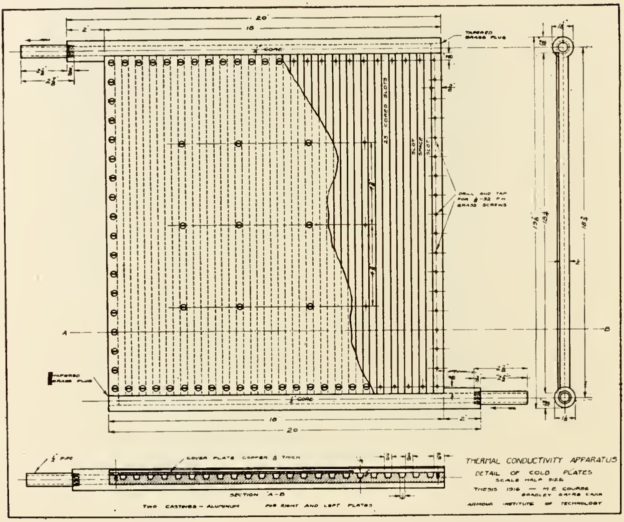

Fig. 3. Detail of Cold Places.

screws. The joints are made water tight by applying white lead ground in oil, at all points of contact. Figure 3 gives the details of construction with arrows indicating the flow of water.

Thermal couple connections are made to several points on each plate, the same will be given under the description of wiring diagram. The plates are mounted in wood frames. Figure 4 shows a view of the assembled right hand cold plate.

Assembly of Apparatus:—Referring to Figure 5 the three plates ready to be assembled are shown. Spacer rods are attached to the four corners of the hot plate, presented in closer

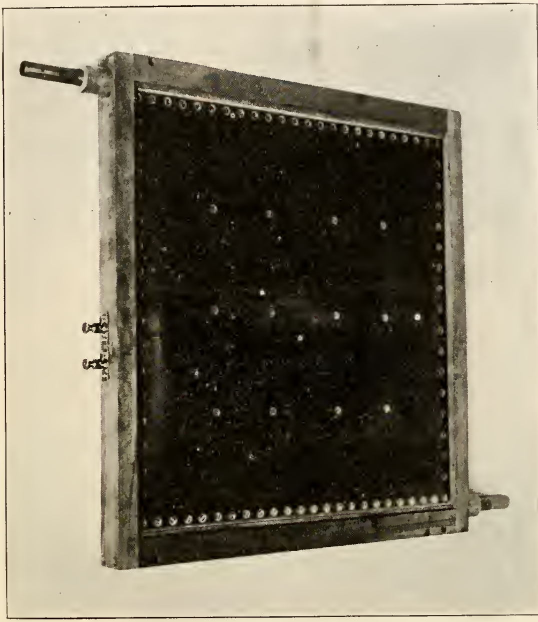

Fig. 4. R. H. Cold Plate.

detail in Figure 2. The rods are ¼″ in diameter and threaded their entire length. Thin lock nuts hold the rods in place on the hot plate.

The apparatus assembled and ready for test specimens is shown in Figure 6. Two pieces of wood 2″x4″ are used as base strips to afford ready manipulation of the wing nuts on the outside of the cold plates. The flexibility of the entire arrangement as to various thicknesses of test specimens is apparent. The spacer rods now in use allow for a maximum of 4″ in thickness of specimens.

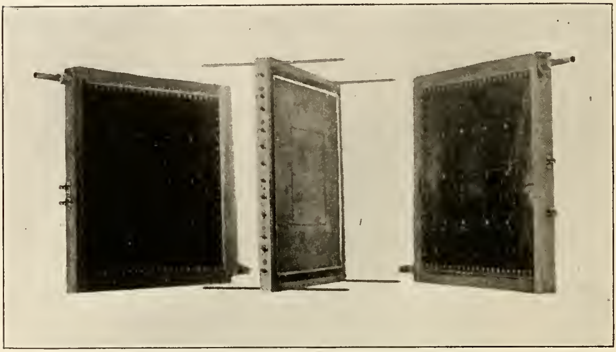

Fig. 5. Three Plates Ready to Assembie.

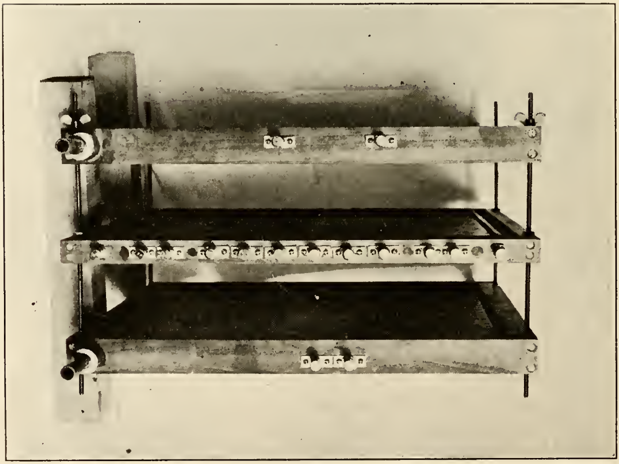

Fig. 6. Apparatus Ready for Test Specimens.

The test samples are cut 18″ square and inserted between the plates and held in place with perfect alignment as to contact with the plate surfaces.

The source of water used is that of the city mains. A supply pipe, with a tee fitting, connects with the inlet nipples of the cold plates by pieces of rubber hose. The same arrangement is used on the discharge to waste of the water. Separate control of the supply to each cold plate is provided for with individual valves on the branches of the supply tee. A master control valve regulates the entire supply. A portion of the water connections are shown in Figure 8.

Wiring Diagram:—The detail of this part of the apparatus is given in Figure 7.

With the hot plate the input to the main heated coil is measured by the voltmeter and ammeter. The auxiliary heater circuit gives the two coils in series with a two ampere fuse wire between posts A_2 and A_3. An ammeter is employed here solely as a guide to the amount of current used. The resistance is regulated until the heat generated in the auxiliary coils gives the same temperature for the test square and guard ring areas of the copper cover plates of the hot plate.

Numbers 1, 2, 3, and 4 = No. 26 Advance wire soldered to the centers of the respective plates as shown. Numbers 5, 6, 7, 8, 9, and 10 = No. 26 copper wire soldered to the various plates as indicated.

All thermal couple leads are run in grooves to the front edges of the several plates to which they are attached, and then cemented in place. The wires are insulated with asbestos thread windings.

The switchboard gives ready access to connecting in testing differences between various portions of the hot and two cold plates, with the use of the galvometer.

Circuit 9-5 is between the centers of the left hand hot and cold plates.

Circuit 10-8 is between the centers of the right hand hot and cold plates.

Circuit 9-6 is between the guard ring and square test area of the left hand cover plate of the hot plate.

Circuit 10-7 is between the guard ring and square test area of the right hand cover plate of the hot plate.

These last two circuits employ the use of the thermal couple connections referred to in the construction of cover plates for the hot plate.

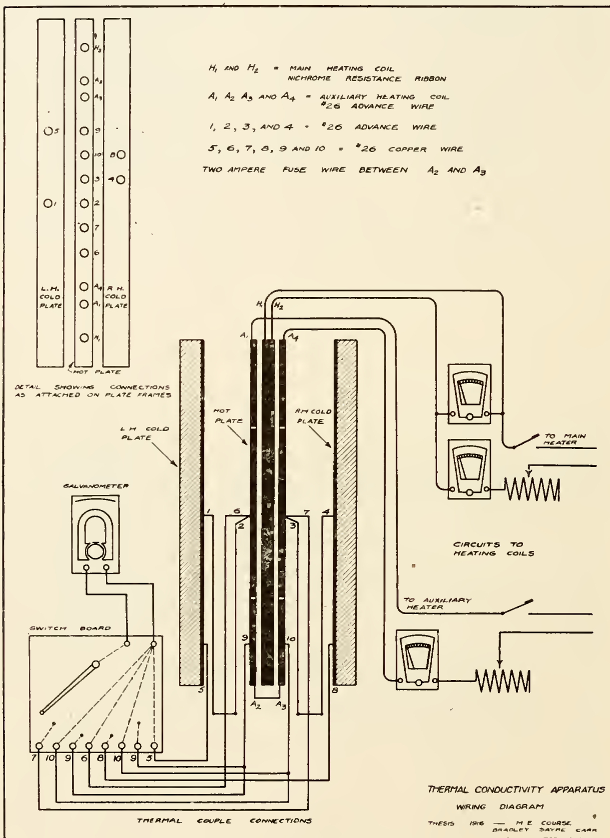

Fig. 7. Wiring Diagram.

Figure 9 gives the apparatus in use with the auxiliary electrical apparatus connected in, as seen in the laboratory.

Calibration of Apparatus.

The accuracy of the apparatus depends upon the relation between the galvometer readings and the temperature differences of the plates as recorded by the thermal couples used.

The essential principle of the thermal couple, is that when two conductors made of different metals are soldered together at their two ends and when those two ends are maintained at different temperatures, an electric e. m. f. (which is very easy to measure exactly) will be generated in the circuit, whose magnitude is proportional for a small difference of temperature, to that difference.

With the apparatus under a test run, the e. m. f. generated by the difference of temperature on the two sides of the test specimen is passed through a delicate galvometer and thus is measured. The magnitude of the deflection in the galvometer gives a measure of the intensity of temperature difference. The e. m. f. produced by the thermal couple is merely a measure of the then existing difference of a temperature between its two ends.

The metals used in making the thermal couples are pure electro-lytic copper wrie and plates, and Advance wire which is a copper-nickel alloy. The uniformity of composition of these metals was tested for by taking wires made of the same and heating them one at a time at various temperatures in an electric oven. Connecting the ends of each wire to a sensitive milli-voltmeter to form a closed loop circuit, gave no deflection at any temperature, showing that there were no local thermal couple actions taking place. Various lengths of the wires were so tested for homogeneity of structure.

In order to obtain accurate results with the thermal couple junctions used in the apparatus, a test thermal couple was calibrated experimentally throughout its whole range of readings. The pieces of No. 26 copper wire were fastened to the ends of a piece of No. 26 Advance wire. One junction was maintained at a constant temperature by submerging it in a receptacle containing water and melting ice. The other junction was placed in a beaker of water, the temperature of which could be varied. Stirrer rods maintained the solutions at constant temperatures.

A Beckman thermometer graduated to read hundredths of a degree Centigrade was held in the cold bath with the cold thermal junction attached to its bulb by means of a rubber band. A United States Bureau of Standards calibrated thermometer, Centigrade scale, was used in the hot bath with a similar means of holding the hot junction of the thermal couple. Both thermometers were compared in the cold bath for zero readings after the same had reached a constant temperature as shown on the Beckman thermometer.

A delicate galvanometer of the suspension type, with a mirror arrangement for reading a graduated scale by the use of a telescope, was connected in to form a closed series circuit with the thermal junctions.

A test run was made as per Table 1, starting with the hot bath at about 50°C. and cooling same down to that of the cold bath. The temperature of the room was maintained constant, and the starting and finishing temperatures of the hot bath were taken at about the same difference above and below that of the room temperature to compensate for any radiation losses.

To check this curve a second test was made starting with the hot bath at a low temperature and increasing the same. Table 2 gives the data as observed. All points fall on the original curve, showing no lag in the galvanometer for any reversal of generation of e.m.f.

A curve to be used in making observations with the apparatus was redrawn from the original calibration curve to a Fahrenheit scale. A copy of this curve is given in Figure 11, showing the relation between galvanometer readings and temperature difference of plates. The range of temperatures shown accounts for about the maximum seasonal differences of temperature met in practice between the interior and exterior of rooms. The curve does not strictly follow the straight line law but has a slight bend in it. The part from 170 mm. to 200 mm. deflection was drawn by an approximate continuation of the part already plotted.

To verify the use of the calibration curve with the actual thermal couples attached to the hot and cold plates of the apparatus, several tests were made with the plates to find if the new readings gave points on the curve.

Calibration of Thermal Couples

Temperature of room constant=30.3°C.

Placing the Standard and Beckman thermometers in same cold bath before making test run, the following temperatures were observed:

Standard thermometer=0.3°C.

Beckman thermometer=1.93°C.

Table I

Temperature °C			Galvanometer
Beckman	Standard	Difference	mm. Deflection
1.93	48.48	48.18	173.5
1.93	47.50	47.20	170.0
1.93	45.80	45.50	163.5
1.93	44.00	43.70	156.5
1.93	41.85	41.55	148.0
1.93	40.35	40.05	142.7
1.93	38.82	38.52	137.0
1.93	36.60	36.30	128.4
1.93	35.00	34.70	122.5
1.93	31.90	31.60	103.0
1.93	29.72	29.42	103.0
1.93	27.40	27.10	94.5
1.93	25.88	25.58	89.0
1.93	23.55	23.25	80.5
1.93	21.85	21.55	74.4
1.93	20.70	20.40	70.5
1.93	16.24	15.94	55.0
1.93	14.80	14.50	49.5
1.93	11.08	10.78	36.4
1.93	8.22	7.92	26.0
1.93	6.30	6.00	20.0
1.93	3.40	3.10	11.0
1.93	2.50	2.20	6.75
1.03	0.92	0.62	1.7
1.93	0.30	0.0	0.0

Calibration of Thermal Couples

Temperature of room constant=30.3°C.

Beckman and Standard thermometers compared as for Table 1:

Table 2.

Temperature °C			Galvanometer
Beckman	Standard	Difference	mm. Deflection
1.93	8.00	7.7	27.5
1.93	12.40	12.1	40.5
1.93	15.40	15.1	51.5
1.93	21.65	21.35	73.25
1.93	28.10	27.8	96.25
1.93	32.30	32.0	112.0
1.93	36.80	36.5	129.0
1.93	39.10	38.8	137.75
1.93	43.10	42.8	152.0
1.93	48.70	48.4	173.25

Temperature of Room=80.0°F.

Table 3

	Temperature °F			
Test	Cold	Hot		Galvanometer
No.	Plate	Plate	Difference	mm. Deflection
(a)	53.3	80.0	26.7	51
(b)	32.0	79.0	47.0	91
(c)	53.2	80.0	26.8	51

(a) Test made with L. H. cold plate and circulating water through same.

(b) Test made with L. H. cold plate using ice bath on copper cover plate.

(c) Test made with R. H. cold plate and circulating water through same.

The hot plate was left to stand for several hours in the laboratory which was maintained at the same temperature. This insured the hot plate to be of constant temperature throughout. Cold water at a constant temperature was circulated through the left hand cold plate long enough for the same to come to a uniform temperature. A galvanometer reading gave a deflection for the temperature difference of the two plates, coincident with a point on the curve for the same temperature difference as plotted.

The same procedure was applied to the right hand cold plate and it was found that the readings taken also gave a point on the curve.

As a further check on the work, the left hand cold plate was placed on a table with the flat test face up. On this surface near the edges a putty dike was pressed on to the copper plate forming a retaining wall to hold a bath of water and melting ice. Directly over the point of attaching the thermal couple was placed a cubical piece of ice about 8″ on a side. A hole was drilled in the ice to accommodate a thermometer. After allowing things to come to a constant temperature another reading was taken. The data given in Table 3 again verifies another point on the calibration curve.

Having made these tests of the plates, the curve plotted for calibration of the thermal couples was accepted to be used in making experiments with the apparatus.

Miscellaneous Calibration Data.—Using the Wheatstone Bridge method, the resistance of the Nichrome ribbon wound on the hot plate core was found per foot and for the total length of heater coil.

Resistance of piece 10.103 feet long=1.94 ohms at 80°F. Resistance per foot=.192 ohms.

Resistance of total length of heater coil=29.85 ohms at 80°F.

The following data was taken from the calibration of Ammeter No. 114:

True Reading	Dial Reading
.2	.2
.4	.41
.6	.61
.8	.82
1.0	1.02
1.2	1.23
1.4	1.43

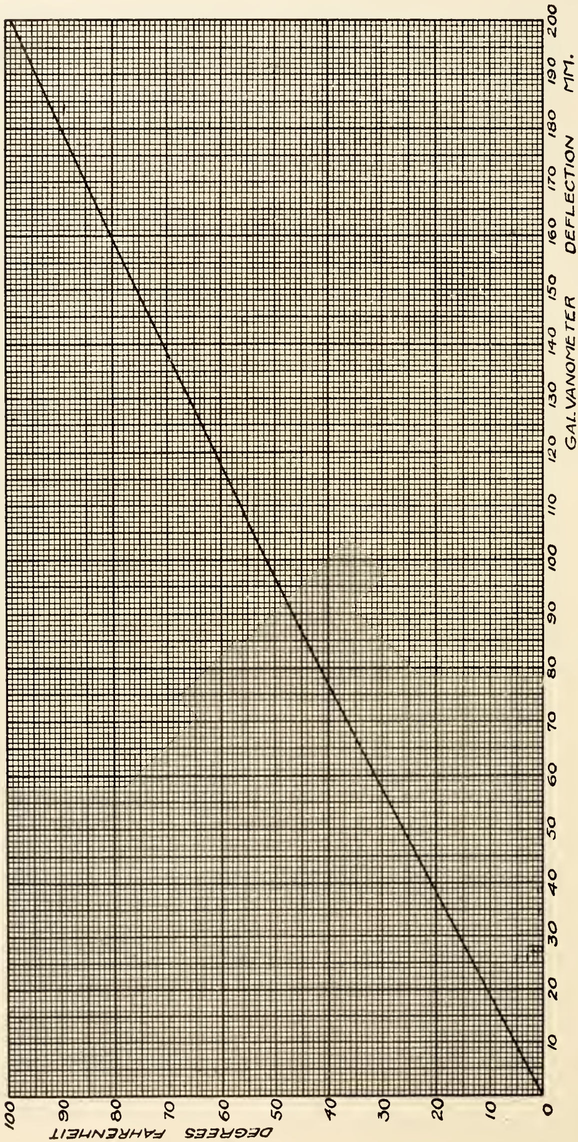

Fig. 8. Relation Between Galvanometer Readings and Temperature Differences of Plates.

Sample Test of Corkboard Insulation

In the application of the instrument as built and calibrated, for measuring the thermal conductivity of materials, the results taken from a sample test are given.

The apparatus set up in the laboratory with all water connections and auxiliary electrical apparatus in position is presented in Figure 12. Two test specimens of Nonpareil corkboard, each 2" thick, are shown clamped in place between the hot and cold plates.

The following instruments were used in making the test:

Leed and Northrup portable galvanometer No. 20802.

Weston ammeter No. 114.

Weston voltmeter No. 20 A. I. T.

Carbon plate resistances.

U. S. B. S. thermometer No. 1962.

The cooling water was turned on and allowed to flow from the discharge pipe at a moderate rate. The current in the main heater circuit was maintained constant at .5 amperes throughout the entire test. The valves to each cold plate were regulated to give a distribution of cooling water such that the galvanometer readings were practically the same between the hot and both cold plates.

Preliminary to making any test readings, the entire apparatus was now left running, holding all conditions constant, for several hours until the galvanometer deflections became uniform. A five hour run was now made and these readings taken; electrical input to main heating coil, temperatures of room and discharge water, galvanometer reading between hot and cold plates. Table 4 gives the data for same.

The temperature difference between the test square area and the outer guard ring for both copper cover plates of the hot plate was a small fraction of a degree as shown by about a third of a mm. deflection of the galvanometer in both cases. Owing to a short in the auxiliary heater coils, the same could not be used in the test to compensate for the slight leakage at the edges of the hot plate.

In the determination of the coefficient for the test specimen, all calculations are based on the flow of heat from the 9" square test areas of the hot plate through the test material to the cold plate.

Across a 9"x9" test square area there are 25½ strips of Nichrome ribbon, each 9" long.

Total length of resistance ribbon across this area

$$= \frac{25.5 \times 9}{12} = 19.11 \text{ feet.}$$

Total resistance for this length

$= 19.11 \times .192 = 3.675$ ohms.

On the square foot basis the equivalent resistance

$$(R) = \frac{16}{9} \times 3.675 = 6.54 \text{ ohms.}$$

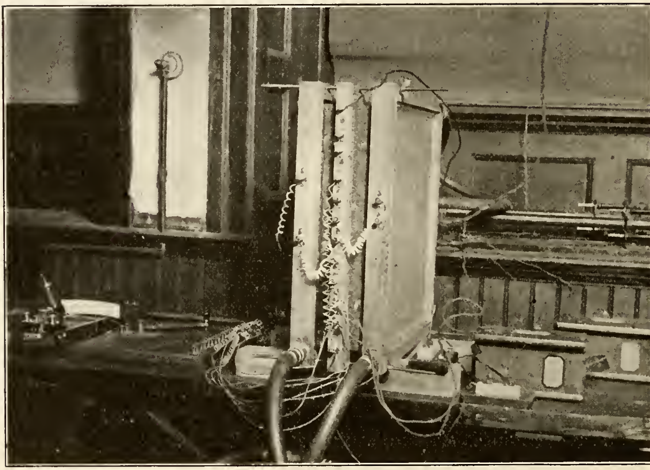

Fig. 9. Apparatus With Specimens Under Test.

Watts input to heater coil $= I^2R$, where $I =$ amperes.

1 watt hour $= 3.415$ B. t. u.

The heat generated per hour per square foot of surface

$= 3.41 \times I^2R$

$= 3.41 \times 6.54 \times I^2 = 22.25\ I^2$

The coefficient (K) or the B. t. u. per hour per square foot per degree difference in temperature passing through any specimen used in test with this apparatus $= 22.25 \frac{I^2}{t}$, where t is the

temperature difference between the hot and cold sides of the material.

In the test, taking the average galvanometer deflection as 52 mm., from the curve, t = 27°F.

K for 2″ Nonpareil corkboard

$$= 22.25 \times \frac{.483 \times .483}{27} = .192$$

Test of 2″ Nonpareil Corkboard.

May 22, 1916.

To main heating coil, Amperes = 0.5

Volts = 14.4

TABLE 4:

Time	Temperature °F. Room	Water	Galvanometer mm. Deflection* L.	R.
11.30	76	56.3	51.0	51.0
12.10		56.2	51.5	52.0
1.10	76	56.2	52.0	52.5
2.10		56.5	51.0	51.0
3.00		55.4	52.0	52.0
3.55		56.2	52.0	51.5
4.20	75.5	56.7	51.0	51.0
4.40	75.5	56.7	51.0	51.0

*L. and R. refer to readings taken between the hot plate and L. H. and R. H. cold plates respectively.

The true reading of current from calibration data of the ammeter = .483 amperes.

Summary.

The data obtained with the short test made on the corkboard agrees very closely with that given by the United States Bureau of Standards on similar corkboard specimens.

Time will not permit of a more extensive set of experiments at this writing, however, the data furnished together with the calibration work give every indication of a most precise method for determining the heat conductivity of various materials.

It is quite possible to duplicate conditions of operation for tests of various kinds and thicknesses of specimens. This method gives directly the heat conductivity of the solid material, this is really what is wanted by the practical man.

THE VALUE OF RECORDS TO AN OPERATING ENGINEER.

BY RAY S. HUEY.*

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When an engineer, after numerous promotions, reaches the degree of success where he becomes the head of the department, he soon is confronted with the problem of costs. There is not a move made nor an article used that does not cost money, and the engineer's value to his superiors is measured by the cost of operating the department under his regime compared to that of his predecessor. Without any previous experience he is unable to put his finger on the high spots and he gropes around in the dark until he gives the matter enough serious thought to formulate some plan to get his costs into some shape that are intelligible to him. If he is of an investigating turn of mind and wishes to know why some things seem to cost more than is necessary, he will soon start some comparative records, probably crude and simple at first. These will be amplified as time and experience require.

Although the final manufactured product may be the same, local conditions make the methods of procedure more or less different, so the engineer must, by necessity, work out his own salvation and adopt methods of his own to suit his own particular needs. It is, therefore, impossible to make a standard that we can say is suitable for all conditions. Any record that is of any value whatever should be accurate. By that I mean that it should be kept up at all times as part of the every day routine and should not be a record of an isolated case of one that has to be dug out of a maze of figures, or data of doubtful value, which, when finished, cannot possibly be as accurate as one that is kept up as part of the regular work.

Unless this is done as routine work, one of the human cogs in machines forgets to do his part at some critical time, and the results of a test or trial always depend on more than one per-

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son, and the record is then incomplete and inaccurate and therefore may be misleading.

When the relative merits of a purchased article are considered, if a record or series of records, on a number of competing articles, are available, it carries infinitely more weight in an argument with the salesman and the purchasing department than an occasional record, because it is clearly to be seen that the chance for error is a great deal less when the record is kept automatically and completely for any and all, whether it is a special test or not.

Special tests, by the way, are, as a rule, quite unreliable and it is generally only after repeated tests that the advantages and disadvantages are fully known.

It is with these thoughts in mind that this paper is presented, to give you a few ideas that have been impressed on me, in the hope that it will be of some assistance to those that desire to obtain more definite information regarding the details of their departments.

When a company expands and builds new plants, the organization is new and more or less inexperienced and there is no one who knows the cost of this or that detail. At the end of the month a statement is received from the accounting department, giving the cost of each item on the cost sheet.

Any detailed costs are obtained only by great effort and are unreliable. I do not mean to cast any reflections on accounting departments, but the ordinary facts and figures from which these details are obtained are not sufficient from which to get accurate results.

As time goes on and experience increases, a system is devised that gives invaluable and reliable records, and costs no more than the old unreliable methods.

In the office may be a clerk, whose duties require him to keep a set of record books that should be up-to-date at all times.

These books are of the loose-leaf variety, composed of sheets on which is ruled and printed in a quantity, or ruled by hand, the substance of the record to be kept. Each machine and part on which a record is kept, should have a separate sheet, and if the number of sheets is large enough, due to the number of machines or to the number of parts replaced, to warrant the ex-

pense of a printed sheet, it is a labor-saver, but for those starting a record it is advisable to rule up the sheets by hand the first time, on account of the frequent changes necessary to get the record into a more or less complete and satisfactory state.

Each sheet should be ruled up to suit the needs of the particular machine of which it is to be the record, and all the parts should be included in it, so that the sheet is a complete record of that particular machine.

In our particular case, each foreman in charge of a number of men in the mechanical, electrical or operating department makes out a mill report, some on printed daily report sheets which are sent to the office for cost and output purposes, such as the operating department, and some on a plain sheet of paper where a printed form will not do, such as the mechanical and electrical departments. The operating department in the "remarks column" makes note of any machine down for repairs and states in general what is being done. On the mechanical or electrical foreman's report, a detailed statement is made showing the pattern number of the parts changed, or any other identifying remarks if it has no pattern number, and the reason for the change, such as broken, worn out, etc.

When the article is purchased from the storeroom, if it has anything special it is tagged with those features explained and this is embodied in the report.

On any very particular or expensive replacement, it is customary to have a copy of the store ticket forwarded to the superintendent's office. These items are very few, but it is another check on the time it was put in. This is also done to call this matter particularly to the Superintendent's attention, as he may wish to make some personal observations of the articles in use.

After the superintendent has made his usual daily inspection of the reports, they are forwarded to the clerk, who enters in his books each item against its respective mill, giving date installed, the reason for its installation, material and any other illuminating remarks in the report.

When a new part is entered as having been installed, it is obvious that the old part is removed and either that it has served the limit of its usefulness or has to be rejuvenated and put back; all of which can be taken care of in the record. If there are a number of the same articles in one machine, the parts

are numbered and the record kept of the numbers and it then makes no difference if the parts are taken out and put in another machine of the same kind, as the record follows the number.

If it is removed on account of its inability to be of further service, the clerk from the mill practice records gets the actual life in hours, days, weeks or months, or it can be worked out to give results in tons made, or barrels conveyed, or any other desirable unit.

If it is desirable to go further, a column can be provided for the unit cost of operation which will work out as cost per hour, day, barrel, ton, etc., which is the figure desired. This can be misleading if the proper unit is not selected, as an illustration will show: A belt conveyor was installed and a number of belts used.. The record had been kept to show the cost per hour of operation. It was observed that the more recent belts were not showing as good cost per hour and, after going over the record carefully and comparing the quantity of material conveyed which, after all, was what was desired, it was found that on account of the increased capacity of the plant at the later date, the later belts had conveyed much more material than the first ones and therefore the cost per barrel was less while the cost per hour was more.

Since the cost per barrel was the unit, it is needless to say the accounting department employed that the costs of all belts after that were recorded in cost per barrel.

After the record had been kept for some time and a study made in some particular, there will be facts standing out so boldly that the wonder is they were not seen before. A different quality, a different kind of material or any other variation out of the ordinary is instantly comparable with years of past experience and it has been the means of reducing the cost of some repairs, not only 10, 20 or 30%, but in some cases 500%. These, however, are rare cases.

Most records not kept in a regular way are kept in someone's memory, and after a set of records has been kept it is very interesting to see how exceedingly unreliable, untrustworthy and misleading the memory can be.

Furthermore, when the record is left to the memory of someone or ones, a salesman may have good reason to believe that his goods are not getting fair and impartial treatment and, in

some cases, it may lead to even more sinister thoughts, but when confronted by actual records, he should have no doubt in his mind that he is being fairly and generously treated. On account of the records, the salesman goes back with a report from which his firm can work to improve the quality of output of the article in question—quite frequently with success. The improved article then helps the operating engineer to get better results which, in turn, decrease costs.

I also believe that you get more courtesy and respect from salesmen or engineers, as they will not take up a busy man's time in trying to sell an article if they can see for themselves that the article is unsatisfactory. On the other hand, if evidence is not at hand, the salesman may confidently believe that the article will be suitable and economical, and he may be right if you cannot argue with any facts to back you up.

A few instances will show how valuable these records may become. A certain mill required 20 heavy, expensive, steel plates which, although made from the same heat, seemed to give very widely different results. It was only by means of the records in connection with experiments relating to mixture, analysis and heat treatment that the service of these plates was increased. Some of these plates lasted a year or more and while they were 3-in. thick at the start, wore to a thickness of less than 1/8-in. before they broke. Others would break and split from end to end in one day and it was necessary to dismantle a machine and install a new plate, which was a long and expensive delay. Analyses were made and the good and bad plates might have the same analyses and no results were obtained from them. A microscope was purchased and the steel of a good plate was examined physically along with the chemical analysis. Then the bad ones were examined the same way and photographs were made. Different heat treatments were then tried, as the physical analyses seemed to show that the steel had not been properly heat-treated.

By comparing the records with the data obtained from these analyses, both physical and chemical, it was noted that progress was being made in the plant. By the continuation of this investigation, the plates were finally manufactured so that they all gave uniformly good results.

The extra service obtained from these plates alone would pay for the cost of keeping the records in the whole plant.

Another illustration, showing the advantage of a record in a minor detail, is one on incandescent lamps. It showed at first that the life of the lamps was very low. Upon investigation it was found that the voltage of the system fluctuated greatly, so a Tirril regulator was installed. The record was then kept of all lamps, 250 watt and above. When a lamp was installed, the date was scratched in the skirt of the base and when it came out this date was also scratched on it. A tag was then attached to the lamp giving location used, date in and out, life in hours and the reason for its failure, if known, such as broken filament, poor vacuum, glass spalled off at leading-in wire, etc., with any remarks when something out of the ordinary occurred. This lamp was taken by the foreman to his office, where he has a book in which he or a clerk enters this information. The lamp with its tag then returns to the storeroom, where it is kept safely until inspected, if desired, by the manufacturer's representative if the life has not been up to its guarantee. When the manufacturer's representative who adjusts these matters, comes to the mill, is shown the records, together with the lamps and actual results on which to base his reports, and a settlement of a claim is always satisfactorily adjusted with the feeling on both sides that there is no guesswork about it.

Another valuable minor record was one kept on fuses. In this mill were approximately 600 a-c., 25-cycle motors. These motors were fairly well loaded, but due to variations in voltage and frequency a very large number of fuses were blown daily. It would have been impossible to have kept in stock enough fuses to last until new ones were purchased and it was necessary to refill the old ones, which was done as needed. The fuses were finally turned over to the storeroom, which placed orders on the shop for refilling and a record of the cost of refilling was made.

All labor and material were charged up and a comparison made of the cost of refilled fuses against new fuses, and also against the refillable fuses.

Records on motors, showing the location where used and causes of failure, will go a long way toward correcting the trouble when the causes are apparent.

During the recent depression, a reduction in the number of men in the shop was imperative so the shop crew was divided into two groups. One group worked two weeks and then the other crew worked two weeks.

By the aid of the shop records, it soon became apparent that certain men were able to accomplish twice as much as the men that worked on the same work the previous week. It was therefore possible to get more out of the slower ones by the competition and to weed out the drones.

Another record of great value is the pattern record. In the ordinary mill, repairs are made at the plant on practically all the mechanical and electrical machinery. The patterns of the parts are made and castings kept in stock either rough or machined. It is one of the most difficult tasks in the plant to get the right casting every time it is needed, and it is frequently the case that the record of the casting cannot be located at all by the man needing it, or the storekeeper. It may be in stock but the man asking for it may not know the name or pattern number and the storekeeper, not being a mind-reader, is unable to satisfy his customer. Pattern records were kept in consecutive order but in this shape they are useless. A number of records were tried with indifferent success but it finally led to a pattern record that seemed to fill the bill for both the mill and storekeeper. A tracing was made on a sheet about 8-in.x10-in. and a sheet made for each mill, machine or motor. On this sheet were recorded every part used on the machine. If the part had a pattern number, it was given with the name or description of the part, material from which it was made, drawing number on which it was shown, the building, the machine it was in, number used per unit and any other remarks. If it was a forging or a coil or some other part, it was listed also under the machine of which it was a part, so when the sheet was complete it was a complete record of the parts of the machine.

These sheets were blue-printed and bound into a booklet with brass split pins with a tough paper cover. These booklets were then distributed among the foremen and to the storekeeper. When the men came to the foreman for a repair, all the foreman needed to do was to refer to his reference book and knowing what machine it belonged to, it was easy to identify the par-

ticular part and send an intelligent order to the storekeeper. It took less time to find out what was wanted and less time for the storekeeper to fill the order and has been very satisfactory.

In conclusion, I want to say a word of warning, as there is a danger of carrying this matter of records too far. When their value is realized and a system is started the engineer may feel that he wants records of everything and then to go to excess in the matter, so that the expense of keeping them up is not justified by the advantages derived.

Therefore, one of the important questions to be decided is what records are of enough value so that the information derived therefrom will warrant the necessary expense of keeping them and, that having been decided, the next thing is just how to keep the records to give the desired information. This last question will eventually take care of itself, as only by a trial and subsequent alteration will a record be found to be complete enough for satisfactory use.

Success means an improvement at each step. You cannot skip any of the steps; you must be thorough in everything you do. You must be reliable in small as well as in large trusts. There is no quality so much appreciated by those who have need of your services, and who are in a position to promote your advancement, which is as much valued as the quality of reliability. If you leave any gaps behind you in your progress upward, they may at some inopportune time be a snare to you; for when you look backward for the supplies which you are depending to be furnished over the road of your past experience, they may be wrecked in the gap which you have left, and you may find that you have reached the limit of your advancement.

—Bates.

EFFICIENCY OF SULPHURIC ACID PICKLING SOLUTIONS FOR IRON AND STEEL CONTAINING ARSENIC.

BY W. H. WIARD

Arsenic in sulphuric acid produces a detrimental effect upon the surface of iron and steel products which undergo a cleaning process preparatory to receiving a superficial metallic coating which is intended to protect the base metal from corroding elements. Lunge explains this injurious effect as resulting from a plating out of the arsenic as metallic arsenic on the iron and as a consequence of this an imperfect continuity of the metallic covering, therefore, a defect in the finished product.

It has become generally accepted by most chemists that .002% arsenic is the maximum allowable percentage which will not cause trouble in producing a perfect coating.

Although enormous quantities of sulphuric acid serves its purpose in this process of pickling iron and steel, only a very few manufacturers buy their acid on a specification covering anything other than a stipulated strength or percent acid expressed as degrees Baume'. Some of the larger users may have learned from experience or by advice of their chemist that they should also incorporate in the specification a clause pertaining to the arsenic content, requiring the arsenic to be present in quantities under .002% or even to such an extent as not allowing the presence of any arsenic. The acid manufacturer, however, is very prone to hesitate about accepting a contract to furnish acid with a guarantee as to the arsenic content and therefore only the large buyer is able to have his demands complied with, or occasion might arise where the manufacturer is forced to concede this point in an endeavor to obtain business.

So far we have discussed only the relation that arsenic bears to the quality of the product. It has another marked influence, one which I believe is generally overlooked, and that is, that it reduces the ability of the acid to dissolve the iron at a rate comparable with an acid free from arsenic. The efficiency of the acid is therefore lowered, so that we see that the cost of an acid cannot be reckoned alone as to its percentage of sulphuric acid but that the arsenic content must likewise bear consideration.

I have made a series of tests to determine at what rate the arsenic reduces the efficiency, figure I is a curve plotted from the data collected and shows that arsenic produces its maximum

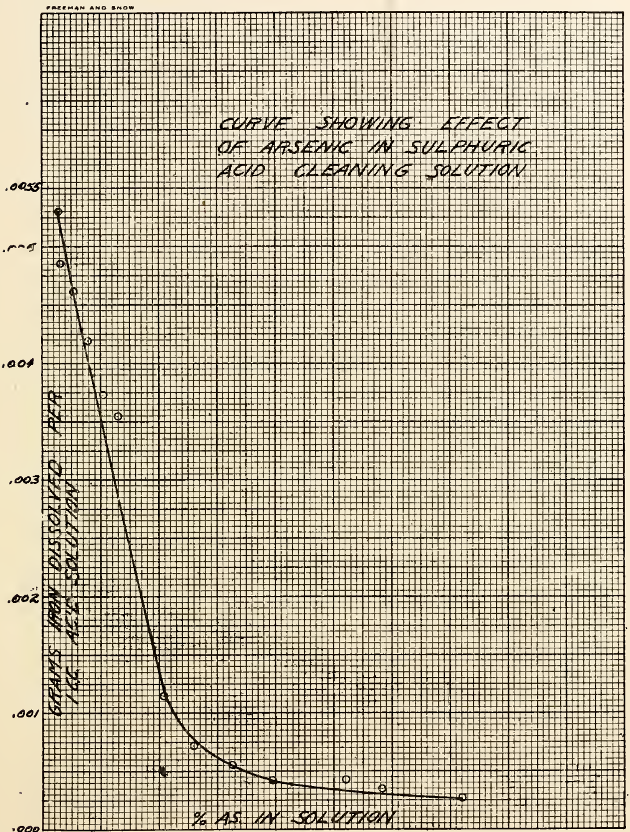

Fig. 1

effect when present in quantities of a trace to .0030%, beyond which the acid becomes almost constant in its ability to dissolve iron.

For the test I selected ten pieces of a bessemer steel bar, analysis showing it to contain carbon .09%, manganese .31%, sulphur .081%, and phosphorous .085%. Each specimen was of exact length and uniform cross section so that each possessed an equivalent of surface area. Two stock solutions were made up from chemically pure sulphuric acid with a strength of 9.0% sulphuric acid by weight. Arsenic was then added to one of the solutions so that one cubic centimeter of the solution contained .0003898 grams of arsenic. The C. P. sulphuric acid was analyzed to ascertain if it was arsenic free.

Sulphuric Acid	94.37 %
Iron	.00049%
Chlorine	None
Arsenic	None
Nitrogen	None
Non-Volatile	.068 %

The ten samples were each submerged in a test tube in a measured volume of 9% sulphuric acid solution and heated in a water bath at a temperature of 185° Fahr. for a duration of two minutes. The samples were then removed, washed with distilled water and the washings added to the contents from the ten test tubes. The quantity of iron dissolved per one cubic centimeter of solution was then determined by a volumetric analysis. Several such tests were carried on to insure the complete removal of any scale and thus get down to the true iron base as otherwise the results would be erroneous. Tests were then made with a small amount of arsenic in solution and the quantities increased to as high as .010719% arsenic.

The results are given in the following tabulation:

Test No.	Grms. Iron dissol'd per l. c. c. sol.	Pct. Arsenic in solution
1	.0054	None
2	.0055	None
3	.0054	None
4	.0054	None
5	.0053	.0003898
6	.0050	.0003898

7	.00486	.0004747
8	.00463	.0007796
9	.00418	.001169
10	.00372	.001559
11	.00356	.001949
12	.00116	.002922
13	.00073	.003898
14	.00054	.004872
15	.00041	.005847
16	.000430	.007796
17	.000324	.008770
18	.000283	.010719

The samples immediately after a test were placed under alcohol to maintain constant conditions and prevent oxidation. Experience proved this to be an essential feature as very erratic results were obtained when using other methods of preserving. After encountering several disappointing tests I learned that it was necessary to conduct the tests at regular intervals with an equal elapse of time between tests. This might quite naturally be expected as it was of course impossible to go from one test to the next without the samples taking on an oxidized coating the condition of which varied with the length of time involved in its formation. Accordingly the tests were made twenty-four hours apart.

Obviously these tests had to be made at one temperature and 185° Fahr. was chosen as that is the one which probably conforms to general practice in pickling. It was, therefore, necessary to determine the influence of heat, if any, and to prove that the effect produced would be proportionate to the temperature. Another series of tests were made similar to the one described. Two sets were tested simultaneously, one set was tested in 9% sulphuric acid and the other set in a 9% sulphuric acid solution containing .001927% arsenic, the temperatures were varied from room temperature to 210° Fahr. The results are shown by the curves in figure 2.

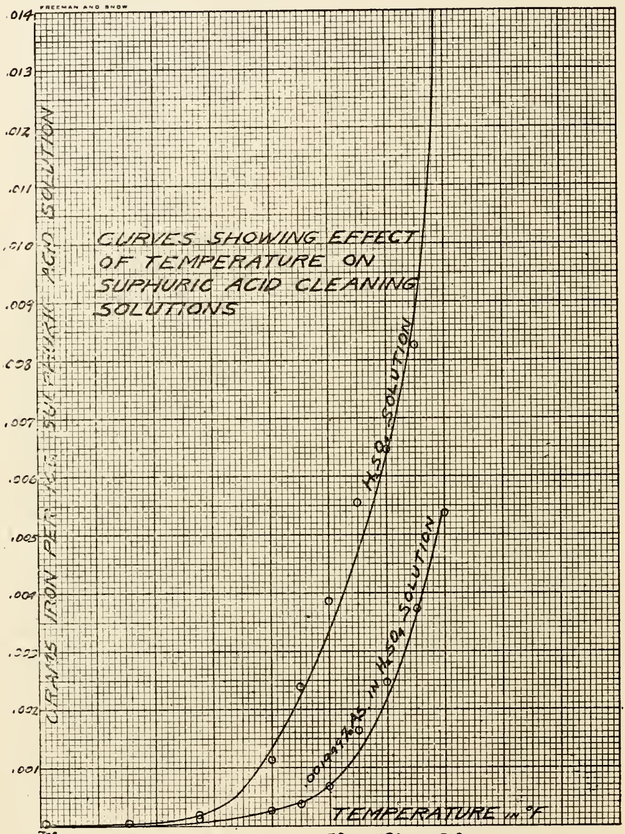
FREEMAN AND SNOW
CURVES SHOWING EFFECT OF TEMPERATURE ON SUPHURIC ACID CLEANING SOLUTIONS
GRAMS IRON PER ... SULPHURIC ACID SOLUTION
TEMPERATURE IN °F
.014
.013
.012
.011
.010
.009
.008
.007
.006
.005
.004
.003
.002
.001
70°
90
110
130
150
170
190
210

Fig. 2

Grams Iron dissolved per c. c. 9% Sulphuric Acid Solution	Temperature Degrees Fahr.	Grams Iron dissolved per l. c. c. Sulphuric Acid with .001927% Arsenic
.000033	72	.0000316
.000040	101	.0000316
.000237	125	.000145
.001136	150	.000270
.00238	160	.000363
.00384	170	.000685
.00555	180	.00163
.00647	190	.00247
.00824	200	.00371
.01660	210	.00537

It is very interesting to note the strong influence that a very small quantity of arsenic produces, the reduction of the power of the acid to dissolve iron being the greatest from traces of arsenic to .0030%. The efficiency of an acid is then dependent upon the arsenic content, which means the efficiency of an operation in the process of production is effected. It demonstrates the necessity of the Purchasing Agent to demand an arsenic free acid.

Do not be discouraged by failure, but endeavor to profit by it; and do not be afraid to tell brother engineers of your failures. It will do you no harm, and may do them good. It takes a brave man to acknowledge a mistake or a failure, but a man who is deficient in that kind of courage would do well to keep out of the engineering profession.

—Waddell.

THE INVITING FIELD OF VENTILATION.

BY W. E. WATT.

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Improved Methods Demanded. The young man who enters the technical school is bewildered by the number of courses and the great variety of avenues which are open for a life work. Ventilation and air conditioning is one in which there is the greatest possible demand for truly skillful work, so that the rewards for one's labors will be great in proportion to one's skill and business ability; and as the science itself is not yet established, the enterprising student will find ample opportunity to contribute to its progress.

Ventilation which does not ventilate is quite common. In fact, so distressing are the results which many cocksure engineers get from their installations that owners and the public look with suspicion upon the claims of all ventilationg engineers; and architects find their most artistic creations injured by the bad work of the ventilating engineer who has merely followed the old paths honored for more than half a century and in which there is little digression form the forms fixed long ago by those who guessed largely at their data.

I will endeavor to present rather briefly a few out of many striking examples of good and bad ventilation, and point the way most beneficial to mankind and yield the best results to the careful investigator.

The form of ventilation most in use today is absolutely nothing but the accidental change of air which comes from the use of doors and windows and the leakage of the building. This is partly because ventilation has the reputation of costing a great deal and partly because the ventilating engineers have not by their work convinced the general public that their ideas are right.

It is this task of making good and of convincing the public that we are making good to which the progressive engineer must address himself. Enough light has now been thrown upon the errors in the text-books to insure a large measure of success and a good reward to those who enter the field in a truly scientific spirit, taking nothing for granted, but proving all things and holding fast those that are good.

Present practice is in many cases misguided by the erroneous belief that if air is pure, right in temperature, and changed often enough, there is good ventilation. There are monuments to this error all over our land. People have paid large sums of money to have installed in fine buildings costly apparatus which supplies more than enough air, controls its temperature as desired, and takes the air from a pure source, high outside the building, often washing it and sometimes ozonizing it and occassionally humidifying or dehydrating it. Yet after all the results are bad.

In such buildings the engineers command that all windows and doors be kept closed and the occupants breathe the pure air which is supplied through the ducts. Anyone who stands on a stepladder and holds his face in the incoming pure air knows there is something wrong. Those who work in the building may be growing nervous, anemic, constipated, dyspeptic, and stupid in that pure, warm, often-changed air, and their condition confirms the suspicions of the one who places his nostrils for a minute in the current of incoming air.

Then comes rebellion or stealthy disobedience. The windows are openly and flagrantly used or they are surreptitiously moved when the one in charge of the plant is not around. Then experts are called in, the movement of the air measured, the method of warming is looked into, the installation is pronounced perfect, and new orders are given to keep the house shut. But soon disobedience is rife and the ventilating engineer says if the people will not obey the rules they cannot expect good results.

Opening a window in one room is said to interfere with the system, robbing other rooms of their fare share of the pure air which is so greatly needed for the well-being of the occupants. Thus it becomes quite common that owners pay for expensive plants which do not satisfy, and the ones responsible for the installation defend themselves with the statement that the plant is not run properly and according to rules.

This has done more to breed dissatisfaction in the public mind regarding costly ventilation than anything else. This is particularly notable in the dealings of architects and engineers with boards of education. Many a board has been persuaded to let the public pay for a plenum pressure plant in the new school building, and have not been told plainly that windows must be

kept shut and that while they are so kept the air will be weakening and stuffy. Because of this there are many small cities with just one building of that sort and it is the most expensive to run and gives the most trouble of all the buildings in town. To extend the work of the ventilating engineer we should see that the public is protected against misunderstandings, and above all we should ascertain the difficulties which militate against good serivce in every plant we install. The weakening effects and the stuffiness must be avoided.

The Errors. The following errors are found in much of the best work being done in this country: 1. Diluting air sewage and using it instead of eliminating it before it diffuses seriously. 2. Failure to provide proper humidity. 3. Use of air that has been devitalized instead of live air. 4. Several serious sources of waste of heat, especially when the building is vacant.

Usually all of these errors are combined in the same plant and the results are that the building is either managed without respect to the rules laid down regarding windows, or there is a very uneven distribution of the "fresh" air. Drafts are common; rooms are stuffy and sometimes downright sickening; the building is overheated; occupants suffer series of colds and other foul air diseases right through the winter; complaints are common of the same room's being too hot and too cold at the same time; while smarting eyes, cold hands and feet, headaches, and general stupidity and nervousness are common. These are not all the complaints, but the main ones.

In such buildings windows will be opened by persons who are too cold but brave enough to withstand rebuke, while other persons complain of the drafts which are harmful to them. It is difficult to get efficient work out of an office force where such conditions prevail. It is still more difficult to get natural school work from children who are subjected to such air. Heat is a mild anesthetic, and children are specially subject to its influences. Stupidity is common in schools so heated and aired and many tragic scenes are enacted over the records of children who have not succeeded and are persuaded that the teacher is unfair or that they are naturally stupid and "born short."

I have in mind such a building which was supposed to be a model one and not excelled in the state. So many complaints came from the building almost as soon as occupied that the board of education suspected the work was not as good as promised, but as the board had ordered that special type of ventilation against the advice of the architect, he was fortunate in being in a position which could not be assailed.

This fine building was warmed and ventilated with air driven over a battery of furnaces to ducts running to the rooms. Fresh air was taken directly from the outside of the house. Being in the country the air was supposed to be clean at the surface of the ground,—a minor error which I have not enumerated because it is one of many whose importance is not great enough to class it with the main ones.

The heated air was driven into the rooms eight feet above the floor level and louvers diffused it about the room. The outlet in each room was in the cloakroom at the floor level. This caused the air in each room to circulate well, the heat coming down from overhead,the floor being cold, especially on wintry days when the wind was strong. To make the house warm enough on the windward side the janitor made the furnaces hot at four in the morning and ran his fan off and on till school time. Sometimes the building was too warm on one side and cold on the other. Some classes were dismissed and others remained to suffer drying kiln conditions. But in ordinary weather the building could be warmed without undue effort.

The worst feature of the building was the smell in the rooms after school had been in session an hour or more. It is true such a building will smell with an uninviting smell before the occupants arrive. But in this school are many children from families where good healthy vegetables of strong odor are consumed freely, and the aroma of these foods, coming from the breathing tracts of children whose digestion had been stopped by the dead air of the school room was, to say the least, quite perceptible. This strong and increasingly persistent smell could not be oxidized nor even ousted by flushing out with open windows.

And yet this building was declared by men fairly eminent in their profession as ventilating engineers to be sanitary and

its air change adequate for the purposes of good ventilation. The errors in the building were all four of those here enumerated.

In another building which conformed to the strict laws of a state requiring much of the ventilating engineer of school houses there was a plenum chamber with all the usual paraphernalia for affording each room an exact amount of air propelled by an adequate fan. The volume dampers had been carefully set to give each room its share, and the thermostat in each room was capable of giving that room warm air till the thermometer registered seventy and then shifting to cooler air till it dropped to sixty-eight, and the damper reversed.

This building was carefully laid out with due regard to the amount of air change required, considerably over 30 cu. ft. per minute per seat. But when cold weather came there was trouble. Several engineers tried in vain to get the rooms to the right temperature at nine in the morning although they began at an extremely early hour and worked strenuously. At last it was decided that there was not power enough in the fan in spite of the fact that it had been carefully computed in advance and a liberal allowance had been made for error.

Because the plenum chamber was small it was thought that the full force of the fan was not brought into play, and so another fan was set on the other side of the plenum chamber to plow air from a second inlet and force it into the plenum chamber in the face of the first fan. After the two fans were working so as to shake the house, the larger one having been speeded up to the limit with a view to increasing its efficiency, the board determined that the whole thing was a failure and the installation was condemned.

Now according to book standards this building was well ventilated. It had just what other fine schoolhouses have. But because it did not warm up well, because the air was extremely stuffy and windows were almost imperatively demanded open by those who taught in the school, and because the vibration from the heavier fan was excessive, the whole engineering scheme was put into disrepute.

These two buildings are fair examples of troublesome buildings erected and equipped according to the standards which make the claim that air from a pure source warmed enough, and

changed often enough is good air. The air was called good by engineers and bad by those who used it. Teachers and pupils worked under serious disadvantages. These buildings had the four errors mentioned; retention of air sewage in air to be used, utter lack of humidity, dead air, and several serious sources of waste of heat and fuel.

Diluting Air Sewage for Use. Half a century ago CO_2 was called a poison. The present ventilation standards were adopted when carbon dioxide was feared. The air change was estimated on a dilution basis, the aim being to prevent the air in the rooms from getting more than eight parts of carbon dioxide to 10,000 of air. As this standard was about as high as costs would permit, it was reasoned that air with only so small a portion of poison in it is reasonable safe to breathe. What would be thought of a city which would mix its drinking water with sewage so there would be but eight parts of sewage to 10,000 of water, saying it is reasonably safe to drink the mixture? Yet it is well known that what we breathe is far more important than what we drink.

Then it was learned that CO_2 is no poison. The air in our lungs is saturated with it all the while and greatly to our benefit. So it was suspected that there is a toxin in used air which accompanies CO_2. No one could measure this toxin, and no one could find it; but its relation to the heavy gas was guessed to be constant and it was inferred that the CO_2 reading would show whether there was much or little of the toxin present. From that time on the test for the heavy gas was used just as it had been used before, but with the explanation that it was merely an index to the supposed presence of the subtle substance that was said to be so dangerous, but still there was no revision of ventilation standards. Air sewage continued to be diluted and used over and over.

To obtain a good mixture the air was driven into the room somewhat above the halfway point between the floor and the ceiling. Diffusers spread it about. The room was kept closed and the air passed out at the floor level. CO_2 is half as heavy as air; so it was thought it must fall to the floor and could be rolled out. Oddly enough the subtle suspected poison was supposed to be dragged down and out along with the heavy gas.

Most of our ventilation practitioners tell you today that the foul air is at the floor. Yet the merest tyro who has ever mounted a stepladder in a warm room knows the foul air is at the ceiling.

The man who remembers his elementary physics knows that gases do not separate into layers as do liquids. They diffuse, if given time, and each occupies all the space there is in the room or container. Although we can pour CO_2 down hill and can carry it in a cup like water, if we leave it awhile in an open dish or lying on the floor, it rises and fills the room so there is quite as much of it at the ceiling as at the floor level, differences in temperature being allowed for. Outdoors it occupies about the same proportions with air one mile above the ground as at the surface. If it were not for this wise provision of nature we should be under a sea of heavy gas and no animal life could exist in our atmosphere.

Exhaled air is but four per cent CO_2, and it comes from our lungs at a temperature of about 98. This is a light load. If the room is at less than 90F. the exhaled air rises. The cooler the room the more rapidly the CO_2 is ballooned upwards to the ceiling. In standard ventilation we find rooms kept tight with but one opening for air to come in and one for its exit. The foul gases being at the ceiling are least drawn upon at the exit, and the best air in the room, that along the floor, is taken out. The foulness hangs overhead, above the line of incoming, cooler air. When it has had some time to cool and some time to diffuse, part of the foul air descends to where it is caught in the whirl of incoming air. Some of it is taken out at the floor line, but much of that which descends reaches the breathing plane and is rebreathed and sent again to the ceiling. The ball in the fountain acts like the air sewage in most of our ventilation plants.

The air sewage should be removed as rapidly as formed and before it has diffused to any great extent. Being a dead gas, it is a slow diffuser. Hence the correction of this error is not difficult.

The Humidity Error. Air that is warmed requires an increase in its humidity to keep it fit for breathing purposes. Zero air

cannot hold much water vapor. But when raised 70 or more degrees it requires more than twenty times as much water to make it of the same relative humidity as when received into the ventilating system cold. In our northern states we often get a northerly wind which has dropped from the Arctic or mountain regions where it has been deprived almost totally of its moisture. 60 degrees below zero causes air to precipitate practically all its moisture. As its descends to our level it has small opportunity to gather moisture and frequently reaches us so that our recording instruments say it has less than 30 percent relative humidity. Now raise this dry air to the temperature required in our houses and you have perhaps two per cent of relative humidity. Such air is far drier than that of any known natural locality.

The vacuum for steam in such air causes it to assail our bodies and our furniture, taking out violently as much water as possible. The breathing tract is dried by it and the mucous membrane secretes water instead of the mucous it naturally produces. The glands enlarge and ulcerate. Then the mucous lining of that part of the breathing tract most affected, instead of being a defense against deleterious microbes, turns traitor and gives aid and comfort to the enemy, affording just the warm wet spot required for a culture and rapid colony increase.

Thus the body is weakened to invite all the foul air diseases. Resistance to fatigue, disease, and even cold is lowered. Then on the surface of the body, under the clothing, there goes on a rapid evaporation which releases latent heat, producing in miniature the ice machine. For this reason some of us are chilly in a room so warm as to cause headache. The texture of skin determines whether a person is a crank for heat or for fresh air.

Now humidity can readily be supplied in many ways, but when the air of a building is changed so rapidly as once in five or seven minutes, it is impracticable to produce enough steam in the air to afford much relief for the sufferers in aridity. The exterior walls of the building collect the dew which this rapidly moving air carries when it has anything approaching 50% of relative humidity. Windows and walls are drenched and then the humidity is usually turned off. The damage to the building is obvious at once when too much humidity is used, while the

damage to human life and efficiency is not so readily noticed when the air is too dry, so the less obvious of two evils is chosen instead of finding a way to afford proper humidity and keep the supply turned on.

A building may have its air properly humidified on a cold winter day with no detriment to the building if its air is not in too violent motion and if the air in the building is in such an ionized state that it carries the humidity rightly. A mere fog in the dead air of the ordinary room does little good and much harm. True steam in invigorating air is highly beneficial and does not injure the building. Here is an inviting field for study and experiment by the enthusiastic young engineer, and the rewards will be great to those who know how to humidify rightly. The limits of this paper preclude going into the matter further than to state the facts which have caused many to install humidifying devices and then shut them off.

The Value of Live Air. There is something in the air of outdoors that our physicians prize highly and do not explain. Why do they regard outdoor air as the only cure for tuberculosis, the great specific for pneumonia, and the general remedy for all run down conditions of nerves which are so common to those who consider themselves well housed. Those who do speak of the reasons for using fresh air to cure usually say that there is more oxygen in outdoor air. This is an error. There is quite as much oxygen in the foulest room as in an equal space of air from a mountain peak. The difficulty is that the oxygen is not physiologically available in the foul room; it is not in condition for use in the body.

Lately it has been discovered that there are special forms of oxygen and nitrogen in outdoor air which are not found in indoor air. Faraday discovered, nearly a century ago, that there are going particles in gases, liquids, and even solids, some of them being quick to seek the positive pole of an electric apparatus and others rushing to the negative. Some travel up the electric current and others down. He named them ions, those going to the anode being called anions, and those going to the cathode cations. But nothing came of his discoveries in this line till the recent development of knowledge regarding rays and radioactivity.

Now it appears that nitrogen is quite as important to the human body as oxygen, and that neither is of much account unless ionized, that is, get going so as to possess radioactivity. The gases of the atmosphere all carry ions, nitrogen mainly carrying negative charges and oxygen positive. Sir J. J. Thomson lists the following as some of the allotropic forms of oxygen found by him in air that has been ionized: O_2 neutral, O_2 with one positive charge, O neutral, O with one positive charge, O with one negative charge, O with two positive charges, O_3, ozone, with one positive charge, and O_6 with a positive charge. Here are eight forms of oxygen peculiarly essential to our physical well-being, but not one of them is mentioned in any of the works on which our standard ventilation is based.

They are quickly changed on the application of even gentle heat. The difference between outdoor air and indoor air is largely a matter of ions. Now the open-minded engineer will enter this field of investigation to secure better guidance. He will gather data and tabulate his facts. He will observe for use in his practice the effects of canned air and live air, and he will avoid the great error which now militates against the general subject of ventilation, for it interferes with good work in all our costly outfits of the standard types.

I use the term live air because it is current. People in the ordinary walks of life speak of live air and dead air, not as if air had or lacked organs of life, but because live air energizes those who breathe it while dead air takes away life. The term ion seems too technical in the ears of those who wish to discuss ventilation, and so it may be best to continue to use the terms live and dead for air which has radioactivity or has it not, or which in other words is abounding in ions or lacking. Air that is ionized is radioactive, but it is probably best to say it is alive.

There is a close connection between ions and humidity. A few years ago our physicists told us that humidity condenses on dust particles to form rain drops. A rounded surface is required for condensation to form the droplet. Now we know that more raindrops form upon ions than upon dust particles. If it is easy to cause the air of a room to carry millions upon millions of times as many ions as dust particles, it is easy to supply the condensing surfaces; and right here we have the

key to the secret of so applying humidity as to get what is desired without making a fog in the air. 25% of saturation is probably worth more in the air of a room which is alive than 50% relative humidity in dead air. It does not drench the exterior walls on cold days.

Wasting Heat Units. Whoever will make a close study of conservation of heat in a building will be astonished at what he will find in buildings laid out by engineers of high repute. To save space I merely touch upon this interesting subject, as it is merely a matter of dollars and cents and does not seriously affect the sanitary condition of the building. The heat thrown away in the night or when the building is not occupied is sometimes almost enough to run the building during the day if proper methods of conservation are applied.

The commonest error in heat waste is that of making a building considerably warmer than it ought to be and then subjecting owners to the losses attendant upon widely opened windows in a frantic attempt to throw away heat and get in fresh air. The air within is largely killed by the heating plant and raised to a high temperature. New air is admitted at windows so as to flood the floor and leave the occupants with their heads in warm strata and their feet in cold. A great deal of air may be blown through a building without sweetening it much; it is still dead and stuffy after flushing the floor. A proper method of airing keeps it pure and invigorating all the time and there is no need of chilling the floor in an attempt to get rid of the stuffiness which is not at the floor but at the ceiling mainly.

We enjoy in summer about ten degrees lower temperature than in winter. This is because the air of summer is usually more alive than the indoor air of winter and it is far more humid. By conditioning the indoor air in winter so as to make it more closely resemble the outdoor air of summer, we greatly increase comfort and efficiency, but we also cause the occupants of the building to enjoy about ten degrees less actual temperature in the rooms. Many schools now enjoy a temperature between sixty and sixty-four but a few years ago they demanded ten degrees more heat. Saving the last ten degrees of heat saves 25% of the fuel. A number of buildings with conditioned air

are saving over half their former outlay for fuel and current. Here is a fruitful field inviting young men.

Some Recent Tests and What They Show. The average man cries out in haste, "Why do you not find some instrument that will tell us when air is bad just how bad it is and when it is good how good?" Your attention is urgently invited to this subject. We have had tests of air for CO_2 content for years and when we supposed that gas a poison we thought we had something. But ever since it was merely supposed that the test told something of the accompanying poison in bad air we have learned that the instruments for measuring this gas are defective enough to render the results uncertain in the hands of most investigators, and furthermore, the existence of the toxin we speculated about is now denied. It is but a few months since its pursuit was declared fruitless, and at the present writing high authority may be quoted admitting there is no such toxin in any considerable amount since the most delicate instruments fail to detect its presence.

Next the instruments with which we measure humidity fell under the displeasure of those who ask for the truth, for they often tell extremely false stories of what is in the air. Professors Starkey and Barnes of McGill university, Toronto, made some extensive tests of the inaccuracy of the wet and dry bulb instruments of various sorts. Their reports to the Canadian Royal society show that these instruments are generally wrong in the low ranges of humidity in warm air while fairly truthful in the high ranges. In the indoor air of winter which we are so greatly concerned about, knowing it to be too dry for our well being, they report that the wet and dry bulb instrument averages about twenty points from the truth, and may exceed forty points, showing a reading above the facts. In one instance where the chemical test showed a 6% relative humidity, the wet and dry bulb instruments read 45%. This was in still air. In moving air results are somewhat better, but not reliable. Spiral instruments set by the wet and dry bulb instruments, are not only wrong at the start, but they soon get out of order and are still worse. Here is a field for genius, no special money reward, however.

Granting that the things supposed to be known a few years ago are not merely under suspicion, but some of them convicted,

the case is far from hopeless. There are results which have been secured in buildings with the finest mechanism for testing that nature can provide, the human body and mind. It still can readily be granted that when a hundred bodies and minds suffer in certain kinds of air an get relief an increase powers in other kinds of air, they point the direction in which we are to travel.

Temperature Tests at Gary, Indiana. In one of the famous schools of Gary, Indiana, an air washer helps the rooms as to humidity. As a rule an air washer wets the air but does not humify it properly—there being quite a difference between a damp room and one rightly humidified. A damp room may be comfortable at a slightly reduced temperature, or it may require quite as high temperature as a dry one, the difference depending on the state of the outside air as to its physical condition.

As this building receives some true humidity along with its dampness from the washer its temperature may be lowered a few degrees without discomfort. There is one class there so large as to occupy two rooms, no special difference being found in the ability of the two divisions. The rooms in which they are instructed may be given a temperature of less than the 68 required by the Indiana law.

Efficiency tests were given these two sets of children with the air of one room at 72, the temperature found in the whole building that day, and the other at 66. The tests were given in exactly the same manner in each room and every incentive given for lively, cheerful work. To be sure of fairness, the tests were given in the presence of the teacher, the principal, and myself, and in the very same manner. The papers were marked by the same system and preserved for future reference.

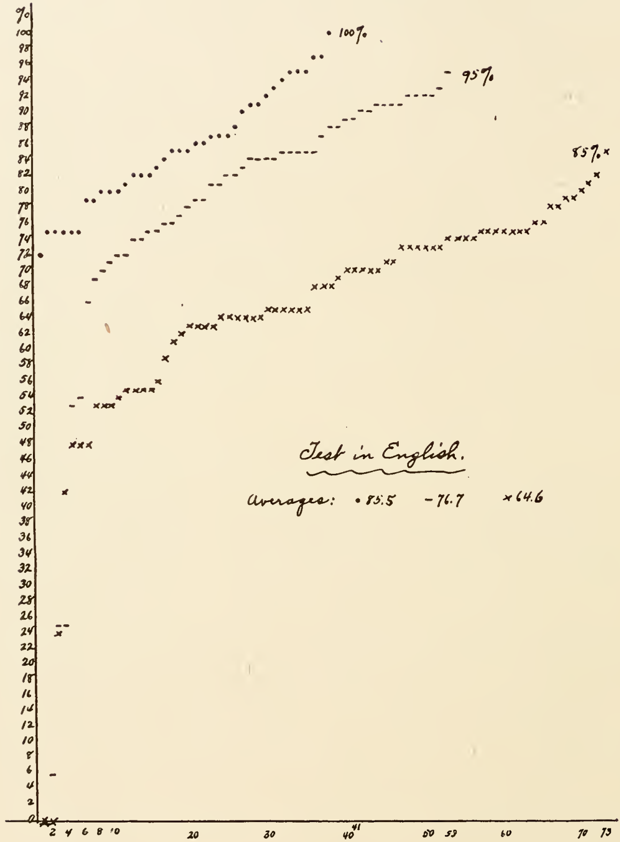
In the first test a single digit, as 3, was placed by each child on his paper and 6 was placed under it with a line drawn for addition. Then another 6 was placed under that sum and a second addition made. Then a third 6 was placed below that sum for another addition, and so on till 63 was reached. After showing the pupils what was desired and giving them some practice, we asked them to take a new number, as 5, and add sixes to it till 65 was reached, and the time taken for each of the pupils who finished in two minutes was noted.

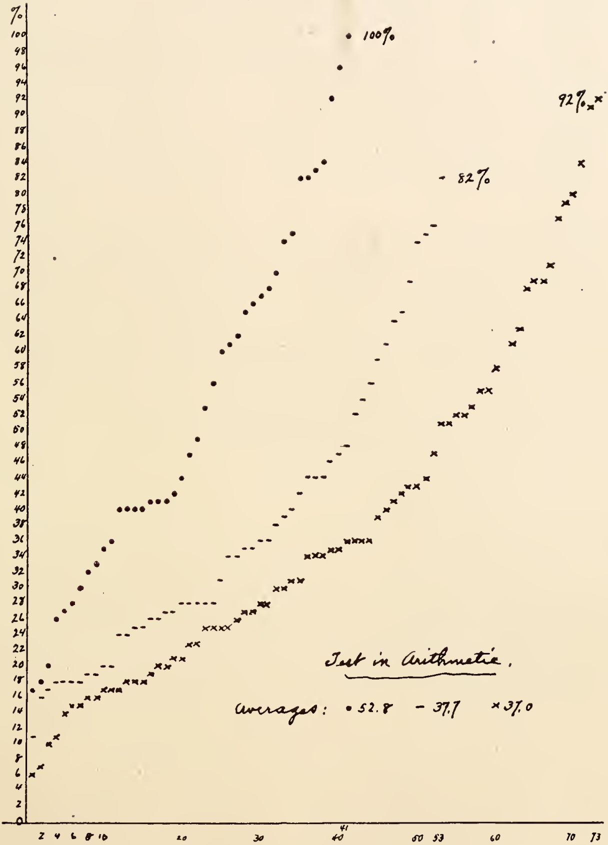
In the cool room 11 pupils finished in two minutes with the following range of seconds: 60, 72, 74, 80, 88, 90, 90, 100, 105, 110, 120. In the warm room 8 pupils finished in two minutes with the following numbers of seconds occupied: 50, 70, 75, 77, 90, 95, 108, 117. A second trial of the same exercise was made in each room with a change of starting digit to 7 and the stopping place 67. In the cool room there was a marked spurt of efficiency, 12 children finishing in two minutes with 40, 55, 55, 60, 70, 75, 85, 96, 101, 105, 110, 120, while the other class fell off in number and time, only seven finishing with seconds: 60, 60, 60, 90, 95, 100, 120. Individual efficiency was gained by some in the warm room, but the average efficiency fell off, as fewer finished. Though the highest rate made by any child was made in the warm room the first, yet that child lost efficiency in the next test, dropping in seconds from 50 to 90.

Three other sorts of tests followed, and the general result was that the pupils in a room six degrees cooler than 72 were able to do anwyhere from 35% to over 100% more accurate work in a given time than their classmates who were handicapped in the heat of 72 F.

Open Air Tests in Four Great High Schools. At the first high school to receive "warm open air" equipment a test was made of sophomores at a given hour of the day, in the presence of the principal, the teacher, and myself, and the papers carefully marked and preserved for reference. The same tests were applied in the same manner and at the same hour of the day on a similar day, as to brightness, in three of the best high schools in three states of the Middle West. The idea was to find out whether open windows and comfort in air that is not cold but yet not so warm as is common in schools would do more for the efficiency of the student.

The following graph of results is interesting and enlightening.


%
100%
95%
85%
Test in English.
Averages: • 85.5 – 76.7 × 64.6


100%
82%
92%
Test in Arithmetic.
Averages: • 52.8 – 37.7 × 37.0

After this high school had been working part of the year in warm open air it was discovered that marks were easier to get and results in the classes were better. Then the teachers were asked how much more they thought their students could do than formerly. Some claimed 25% and others 100%. As a result directions were given to raise the requirements for passing one-fourth or one-half and see the progress under such added load. At the end of the semester the marks of all pupils were averaged and compared with those secured in the same semester by all pupils the year before. Although the school was doing one-third more work the average mark was more than two per cent higher. The work in mechanical drawing was doubled and better done.

On the whole, there is much to be done in ventilation, and the field is a very inviting one for the young man who is willing to study and prove for himself. It is a sad commentary on our civilization that when a man has built a fine house nobody can remain in it long and be well. We have to get outdoors to be well. Now it is practicable to make the indoor air conductive to health and efficiency, and this is the great task of the ventilating engineers of today and tomorrow.

The employer expects of the young man, fresh from his technical education, ability to understand, capacity to think, the possession of ordinary facts regarding ordinary things, logical procedure in his acts, faithfulness in performance, accuracy in observation, and general intelligence.

—Kerr.

WATER SOFTENING.

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(Continued from November issue)

The Chemistry of Water Softening.

Water is rendered hard by the absorption and solution of the various foreign substances which it encounters in its descent through the air and its subsequent passage through the earth. It may be made soft again by the addition of certain chemicals which will cause the precipitation of the hardening substances which have been absorbed.

The most common hardening materials encountered in waters are Calcium Carbonate (chalk or marble), Calcium Chloride, Calcium Sulphate, Magnesium Carbonate, Magnesium Sulphate and Magnesium Chloride.

The first of these, Calcium Carbonate or chalk, is not directly soluble in water, but becomes dissolved through the aid of Carbon Dioxide gas, which it absorbs in its fall through the air, which, uniting with the water (H_2O), forms Carbonic Acid (H_2CO_3). Passing through the earth, this Carbonic Acid in the water encounters limestone ($CaCO_3$), which is insoluble in water. The acid dissolves it and forms a bi-carbonate of Calcium, which is soluble in water. This being the case, the addition of any substance that will remove the Carbonic Acid will change the soluble bi-carbonate of Calcium into the insoluble Carbonate of Calcium and thus render it an insoluble salt again.

Caustic lime (builders' lime) is the cheapest and most convenient of these substances and is the one most commonly employed. Added to water containing Calcium Bi-Carbonate in solution, it destroys the Carbonic Acid and forms water and a precipitate of Calcium Carbonate.

$$CaH_2(CO_3)_2 + CaO = 2CaCO_3 + H_2O.$$

For this reason, to remove the Calcium Bi-Carbonate found in the water, a quantity of lime is added proportionate to the amount of salt in solution and the amount of water to be treated. Lime has a similar reaction with Magnesium Bi-Carbonate and is added to remove this salt as well as the Calcium.

$$MgH_2(CO_3)_2 + CoO = MgCO_3 + H_2O + CaCO_3.$$

The other incrusting or soap destroying solids commonly met

with in water, as stated before, are Calcium Sulphate and Chloride and Magnesium Sulphate and Chloride. The Sulphate of Calcium causes scale of the worst formation, it being a hard, dense scale and an extremely poor conductor of heat.

Soda Ash (Na_2CO_3) will react or join with any of the four salts mentioned above and form two new compounds in each reaction. One of the two thus formed will be soluble but non-incrusting and the other will be insoluble and is precipitated out as a white floculant precipitate. For instance, added to water containing Calcium Sulphate it forms Sodium Sulphate (Na_2SO_4), a substance that does not form scale and therefore can safely be left in the water, and insoluble Calcium Carbonate.

$$Na_2CO_3 + CaSO_4 = Na_2SO_4 + CaCO_3.$$

The latter, Calcium Carbonate, is a precipitate similar to the others and settles out.

If the soda ash be added to water containing Magnesium Sulphate the same results as in the case stated above are obtained. That is, a soluble, non-scale forming salt is left in solution and an insoluble precipitate formed.

$$Na_2CO_3 + MgSO_4 = Na_2SO_4 + MgCO_3.$$

The soda ash will also take care of the Chlorides of Calcium and Magnesium. If added to water containing Calcium Chloride the same results as stated before will be obtained.

$$CaCl_2 + Na_2CO_3 = CaCO_3 + 2NaCl.$$

We have the insoluble precipitate of Calcium Carbonate and the soluble salt, Sodium Chloride or common table salt.

Added to water containing Magnesium Chloride we have

$$MgCl_2 + Na_2CO_3 = MgCO_3 + 2NaCl,$$

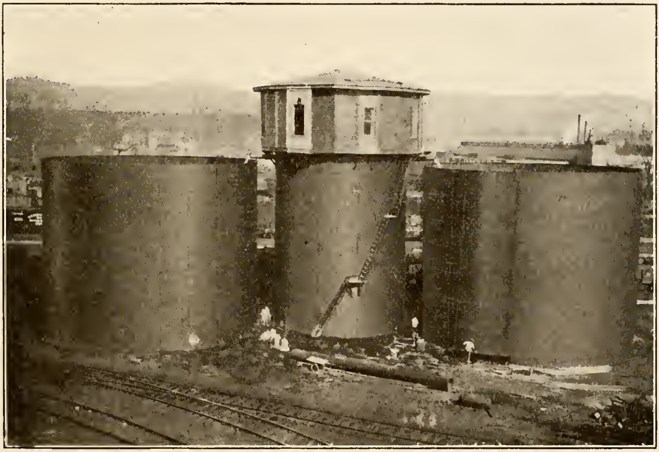
which is analogous with the previous.

The above shows the reactions and results of the water softening chemicals and the more common scale forming elements. These chemicals will also remove other substances frequently found in water but a discussion of all the reactions would be a superfluity. In only rare cases is a water found that cannot be treated satisfactorily with lime and soda ash, when added in the correct proportion.

In the chemical treatment the salts contained in the water were simply mentioned, with no explanation as to their characteristics. In the following paragraphs the salts are enumerated and a description of them given.

Calcium Carbonate.

Carbonate of lime is the commonest form which lime appears in water. It is but slightly soluble in chemically pure water, but when carbonic acid is present it dissolves as a bi-carbonate. Bi-carbonate of lime, when carried into the boiler, is decomposed by heat, the acid is driven off with the steam and common carbonate of lime is precipitated in the boiler. This reaction is practically complete when a temperature of 300 degrees is reached. This salt alone does not form a very hard scale but is responsible for a great deal of the mud found in boilers. It may form a very hard scale when in the presence of other salts which serve to cement it to the shell and flues of the boiler.



Calcium Sulphate.

This salt is a very common constituent of natural waters and is responsible for the hardest kind of boiler scale, in some instances the formation has been as hard as porcelain. It is almost entirely precipitated when a pressure of fifty pounds is obtained in the boiler, precipitation being in the form of heavy crystals fastened to the sides of the boiler, forming a scale of

great hardness. Sulphate of lime attaches itself to the metal much more readily than carbonate of lime.

Calcium Chloride.

Chloride of lime is sometimes found in natural water in which which it is very soluble. It is classed among the corrosive minerals found in water, but does not of itself form scale. In the presence of sulphates, a transfer of acids takes place and calcium sulphate is formed and acts as described above.

Calcium Nitrate.

Calcium nitrate rarely occurs and is of very little importance, as the quantity is usually very small. It, itself, does not form scale, but when sulphate of soda is present an exchange of acid takes place in the boiler, and the nitrate is converted into sulphate of lime and its action is corrosive.

Magnesium Carbonate.

Magnesium carbonate is much more soluble in water than Calcium carbonate, but is ordinarily found in water as a bi-carbonate. The bi-carbonate decomposes in the boiler under high temperature just as in the case of calcium. The resultant precipitate is very unstable in boilers and is readily decomposed into carbon dioxide and magnesium hydrate or magnesium oxide, the magnesium compound usually found in boilers. Magnesia is extensively used for lagging of boilers and pipes to prevent radiation, so it can easily be seen that it is a compound that should be kept out of the boiler.

Magnesium Sulphate.

This salt is a common constituent of water and is extremely soluble. It does not form scale of itself, but in the presence of lime salts it is broken up and a lime scale results.

Magnesium Chloride.

This is a very objectionable mineral to have in boiler feed water, being very corrosive in its action, quickly pitting and grooving boilers that use water containing it.

Magnesium Nitrate.

The action of this salt in boilers is very similar to that of magnesium chloride.

Iron and Alumina Sulphates.

These salts, $Fe_2(SO_4)_3$ and $Al_2(SO_4)_3$, act exactly as free sulphuric acid in a boiler. The action of sulphuric acid will fol-

low in a subsequent paragraph.

Iron and Alumina.

These minerals are usually present in water in the form of bi-carbonates, but iron bi-carbonate is a very unstable compound and readily gives off its excess of carbonic acid, and absorbing oxygen, is converted into iron rust. This is the cause for many waters turning red when standing exposed to the air for a short time. This salt causes boiler scale. Alumina is present in minute quantities and forms scale similar to the iron salt.

Silica.

Common sand is nearly pure silica. Silica is contained in almost every water, in varying degrees and to the greatest extent in warm water. It is frequently in combination with alumina but usually appears in such small quantities that it has very little to do with the formation of boiler scale.

Suspended Matter.

This is either organic or inorganic matter held in suspension in water and is found in variable quantities depending on the source of supply of the water, the rainfall and the season. Suspended matter forms scale only when it is cemented to the surface by other materials in the water.

Free Sulphuric Acid.

This is the most dangerous compound that can enter the boiler feed water. This non-volatile acid occurs most frequently in mine waters and in the effluent of coke ovens; also in rivers of coal mining districts. When introduced into the boiler, it immediately attacks the metal, forming sulphate of iron, which by decomposition yields hydrate of iron and the sulphuric acid again, and this reaction is repeated over and over through an indefinite number of destructive cycles. Hence the deadly effect of a slight amount of sulphuric acid.

Sodium Sulphate, Chloride and Nitrate.

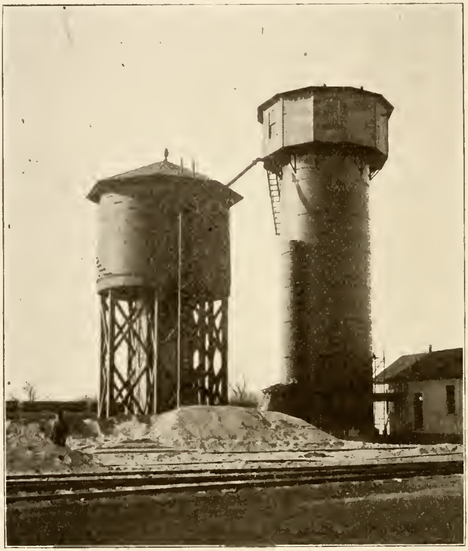
These salts do not form boiler scale and do not corrode iron. They are not objectionable in feed water except when present in large quantities, in which condition they cause foaming and priming of the boiler.

Sodium Carbonate.

This salt, common soda ash, is not objectionable unless present in sufficient quantity to cause foaming of the boiler.

Free Carbon Dioxide.

The presence of this gas in boilers favors pitting and corrosion, but common lime and soda ash treatment removes it entirely.



Half bound carbon dioxide, which is held in an unstable condition by the calcium and magnesium salts, upon liberation has the same effect as carbon dioxide.

Hydrogen Sulphide.

This gas is very rarely found in water and is usually in very small quantities when present. It is very unstable and is readily decomposed into water and sulphur. Any injurious effects of hydrogen sulphide water can easily be overcome by treatment.

The Modern Water Softener.

The modern water softener is a machine of steel and iron construction; chiefly an apparatus that automatically and accurately adds chemicals to the water as it flows into the machine.

There are a great number of machines on the market, of different design and operation, but the general principles of all of them are the same. In order to make the description and operation as clear as possible an illustration is made use of showing the cross-sectional view of one of the well known makes of softeners. It is known as the quartz filter type, overhead operated machine. Some of the machines have the upper works entirely on the ground and these are called the ground operated type.

The water softener consists of:

(1) Shell or tank.
(2) Upper works.

The shell consists of:

(1) Outer shell or tank (1).
(2) Downtake (2).
(3) Special designed bottom for removal of sludge (18).
(4) Valve for removal of sludge (3).
(5) Filter compartment (19); filter materials (15 and 16); strainer system (6).

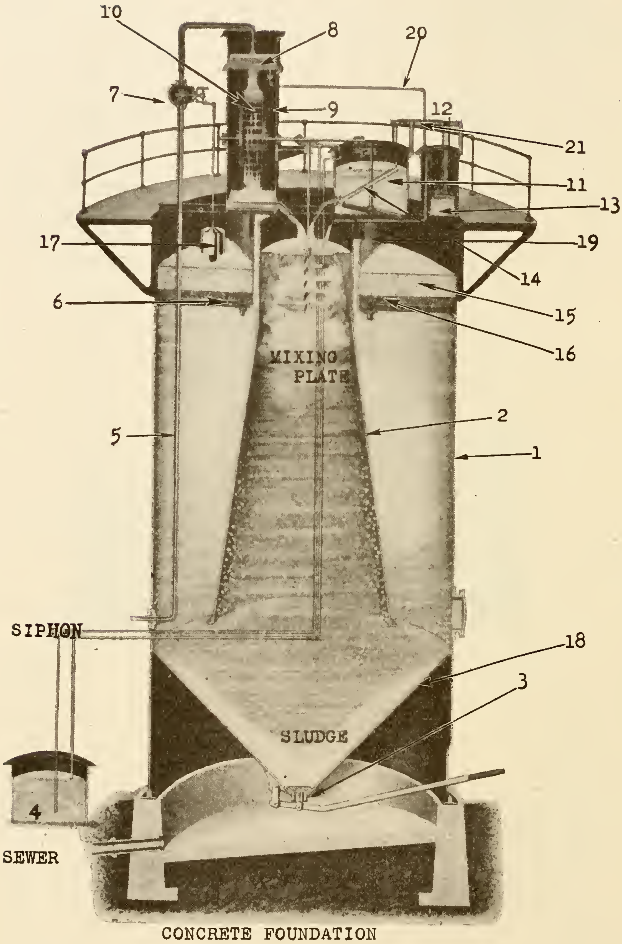
The upper works consist of:

(1) Chemical tanks (11 and 14).
(2) Means for agitating chemicals (8, 9 and 10).
(3) Apportioning apparatus (12, 13, 20 and 21).
(4) Mechanism that automatically starts and stops machine (17, 7 and 5).

(The numbers following the items refer to the numbers in the illustration.)

The shell of the machine merely serves the purpose of storing the water and giving it the proper time for the settling of the precipitate formed by the reaction of the chemicals.

The downtake directs the flow of the water and does it in such a way that will give the best results as regards sedimentation. The water is constantly moving and it is necessary that the flow of the water be slow enough to allow proper settling. It is in this respect that the downtake has its function. Different styles of downtakes are used and each design has its advantages.


10
8
20
7
9
12
21
11
13
17
19
14
6
15
16
MIXING
PLATE
2
5
1
SIPHON
18
3
SLUDGE
4
SEWER
CONCRETE FOUNDATION

The bottom and valve arrangement are simple, the sole purpose of this part of the machine is to conveniently expel the sludge, which consists of the precipitate, and the suspended matter which the filter removes from the water. The valve is the usual type of quick opening, self seating, cone plug valve.

The filter most commonly employed at present is the gravity or pressure quartz filter. A separate compartment is constructed in the top of the machine and the strainer system, quartz and gravel layers placed in it. This is the gravity type, but is no different from the pressure type, except that that type is made in an enclosed shell and designed to work under pressure. The strainer system, as the name implies, serves to take the water from the filter over its entire area. This system is imbedded in this layer of gravel is a 16-inch layer of very fine mesh, crushed quartz. This is the filtering medium, the gravel serving to help the straining action and to prevent the quartz from working into the small holes of the strainers, or in other words, prevent "plugging" of the strainers. Some of the machines still use the excelsior layer for a filter bed, but this type is gradually being replaced by the more efficient type of quartz filter above described. With the quartz filter a clear, bright water is insured for either the boiler or the manufacture.

The "upper works" of the machine is the important part, because the accuracy of the softener depends on the operation or this mechanism.

This apparatus consists of four distinct parts, as stated in outline. The chemical tank usually contains a charge of chemicals suitable for a twelve-hour treatment of water. The agitating mechanism serves the purpose of keeping the chemicals from settling while they are being fed into the water. There are a great number of these devices, water wheels, paddles, the water itself and electric motors. In the machine shown in the illustration the water drives a wheel which through beveled gears, shafting and agitators, keeps the chemicals well mixed.

The opportioning apparatus adds to the water, upon its entrance into the machine, a certain positive and accurate amount of the two chemicals in direct proportion to the amount of water. Various machines use different means of feeding these chemicals, the one used in this description being explained later under the head of "Operation."

The apparatus that automatically governs the operation of the machine consists of an arrangement of floats, simple levers and balanced float valves. It is similar to all other float arrangements, except that in this case the softener is operating under a 100% load at any time that it is in operation, and is therefore not forced to run at inaccurate, partial loads. This is accomplished by a double float and single float pot, one of the floats governing the water in the pot, which level governs the main control float.

Operation.

The water enters the softener through inlet (5), passing balance float valve (7), and flows into the "raw water box" (8). Here a small part of the water flows into the apportioning apparatus and the rest falls on the water wheel (10). This wheel is forced to rotate and agitate the chemicals.

As the water leaves the wheel it flows into the downtake (2) where it meets the flow of chemicals.

The water that is supplied to the apportioning apparatus, from the "raw water box," flows into the "regulating tank" (3). Located in this tank is a float (12) directly connected to a "lift pipe" (4) in the chemical tank (11). As the required amount of water runs into the regulating tank, in direct proportion to the volume flowing into the downtake, the float is raised a certain definite amount, consequently the lift pipe is lowered the same distance and an accurate quantity of chemicals is added to the water. The charge of chemicals is previously prepared in the termined by analysis. In actual practice this charge is prepared at ground level and raised to the top of the machine by means of a steam siphon.

This addition of chemicals is continuous as long as the machine is in operation, but as soon as the supply is checked the supply of chemicals is automatically cut off.

When the water and the chemicals meet in the down-take and strike the mixing plate, or agitators, they become thoroughly mixed and a white floculent precipitate results from the chemical reaction. As this mixture descends at a gradually reducing rate, due to the conical shape of the downtake, the precipitate settles to the bottom. The water is reversed in direction of flow

at the bottom of the downtake and proceeds upward, still at a rate slow enough to allow sedimentation.

Upon reaching the top of the shell the water spills into the filter compartment, flows downward through the filter bed and emerges a clear, bright, soft water suitable for almost any use that is desired.

This operation for one particular machine will hold in general for a number of other softeners on the market.

From a field that twenty-five years ago was considered very slightly, the water softening industry has developed until it is foremost in the minds of engineers, and owners of manufacturing plants all over the world. There are a great number of concerns engaged in this business, in every country, and all have good machines. Competition is very keen, and above all it clean, which helps to make it interesting.

What has happened in this industry in the last twenty-five years will surely be outdone in the coming period, judging from the recent developments that have been made in this field.

Railroads all over the country are installing water purifying equipment at the water stations. Enormous sums of money are being spent annually for the building and maintenance of this equipment and the results obtained certainly verify the expenditure. Some of the roads have employed a staff of chemists whose sole duty is to operate these plants and keep them in operation.

To every man going into engineering it is a subject worth knowing, because water plays an important part in nearly every branch of that profession.

It is the desire to act that causes activity, and nothing but action can produce results.

—Kerr.

A TELEPHONE CALL.

BY JAMES W. COHN.*

Switchboardman, Monroe Office, Chicago Telephone Co.

PART II.

"B" Board Operator's Telephone Circuit

"B" Board Trunk Circuit

Four-Party Bunch Block Circuit

Called Subscriber's Circuit

(Part I appeared in the November Issue)

The "B" Board operator's circuit is a part of the connecting link between the "A" board of one office and the "B" board of the same or another office.

We recall, that Part I traced the call from its origin or the Kedzie subscriber through Kedzie "A" board to the "B" board at Haymarket exchange. The "B" board operator's telephone circuit terminates on the "B" board end of the call circuit, in the same "B" board position in Haymarket exchange that the outgoing trunks from Kedzie "A" board to Haymarket "B" board terminate. Hence, when the "A" board operator at Kedzie exchange presses the call circuit button marked "HAY" she connects her telephone set through a pair of conductors to the telephone set of the "B" board operator who is nearest to the trunks from Kedzie office. Referring to Fig. IV., when the "A" board operator at Kedzie exchange presses down the Haymarket order wire button, the springs on the call circuit key make contact, which connects the "A" board operator's telephone set to the order wire, through a contact of a switching key through a winding of No. 24 induction coil to the receiver circuit which is arranged to be antisidetone in a similar manner as the "A" board operator's telephone circuit discussed in Part I. The switching keys are located in each "B" board position, and makes it possible by operating the cam on the key, to switch the call circuits of several "B" board positions into one position, so that one "B" board operator can operate more than one position when the traffic is light. The No. 18 D resistance coils are located at the "A" board end and are connected in series with the call circuit conductor, thus balancing the circuit. The necessity for balancing the circuit may be explained as follows: Let us assume that the

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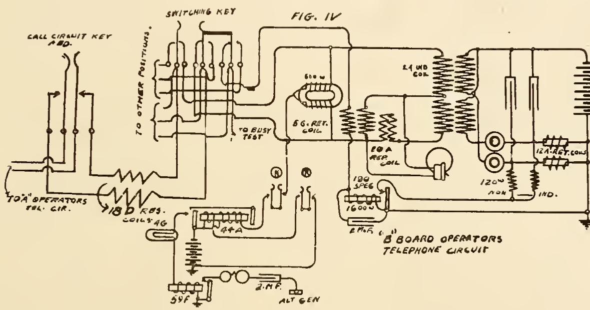
*Class of 1917.

order wire from Kedzie exchange and the order wire from Austin exchange are both connected to the same Haymarket "B" board position. The loop to Austin exchange would have a greater resistance than the one to Kedzie exchange, due to an additional length of conductors; hence, if an operator from Kedzie exchange and an operator from Austin exchange were connected to the Haymarket call circuit at the same time, the electrical speech fluctuations would not reach Austin exchange due to its being shunted out at Kedzie exchange and the Austin "A" operator would not be able to transmit her order. To eliminate the above difficulty the outgoing call circuit from Kedzie to Haymarket would have No. 18 resistance coils connected in series with it before it is connected in parallel with the outgoing call

FIG. IV



circuit from Austin to Haymarket, thus making the resistance of both loops approximately equal.

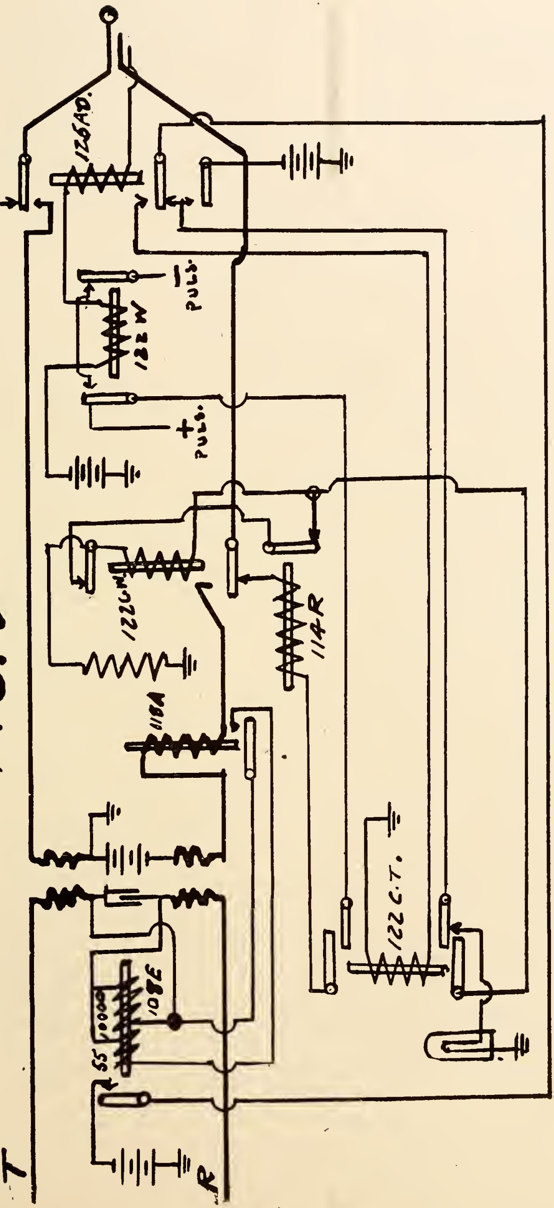
The No. 5 G retard coil, Fig. IV., is connected permanently across the secondary side of the "B" operator's telephone circuit, and in connection with an auxiliary circuit gives the operator a signal and an alarm for night service, when the traffic is not heavy enough to require all the operator's time. When the end button is operated for night service, and the "A" board operator wishes to transmit a call to the "B" board operator at Haymarket exchange, she presses down the Haymarket call circuit button and operates a listening key which puts a ground on the call circuit. Current will then flow through the winding of the No. 44 A relay, Fig. IV., through the contact of the button, through a 500 ohm winding of the No. 5 retard coil, through a contact of the switching key to the ground on the circuit at the "A" board

end. The No. 44 A relay will operate and allow current to flow through its contacts through the 4 G lamp, through the winding of the No. 59 F relay to ground, which lights the lamp and operates the No. 59 F relay. Generator then flows through a 2 M. F. condenser and a set of ringers to ground, which gives the "B" operator a night alarm and notifies her that she is wanted in the position where the lamp is lit. After answering the call, she restores the No. 44 A relay by operating the restore button (R) which opens the lamp circuit and allows the 59 F relay to become normal, thus stopping the ringing. The No. 5 G retard coil does not interfere with the electrical speech fluctuations due to its high inductive windings.

The transmitter and receiver circuits of the "B" board operator's telephone circuit is similar to the "A" board operator's telephone circuit, in all respects with the exception of the busy test which will be discussed with the "B" board trunk circuit when the busy test is made.

We arrived at the point, in the transmission of our call, from Kedzie 1 to Haymarket 1 where the trunk was assigned by the "B" operator and the "A" operator after testing the assigned trunk inserts the plug of the answering cord in the trunk jack. Current will flow from the ring of the plug, over the ring side of the line, through one winding of the repeating coil of the "B" board trunk circuit, Fig. V., through the 10,000 ohm winding of the 108 E relay, through the other half of the repeating coil over the other or tip side of the line, to the ground on the top of the answering cord at the "A" board end, which will operate the 108 E relay and allow current to flow through its contacts, through a contact of the 125 A. D. relay through a back contact of the 122 C. T. relay through the trunk lamp associated with the assigned trunk, to ground; which lights the lamp, thus notifying the "B" board operator that the trunk she has assigned was accepted. The "B" board operator then tests the line called by touching the sleeve of the jack with the tip of the plug of the assigned trunk. Three conditions pertaining to the line may exist. First; the line may be out of order, in which case there is a plug in the jack of the line in the hospital position which puts tone test on the sleeves of the ack of the line in which the
puts tone test on the sleeves of the jack of the line in which the
sists of a direct current interrupted about 4,800 times per minute,

FIG. V



B BOARD TRUNK CIRCUIT

flowing through a 1030 ohm coil, which current is induced in a 1/3 ohm coil which has a current flowing through it, and is connected to the sleeve of the hospital cords. If there is tone test current on the sleeve of the line being tested, it will flow through the tip of the plug, Fig. V., through a back contact of the 125 A. D. relay, through Point 1, Fig. V., to point 1, Fig. IV., through a contact of the switching key, through a winding of the No. 20. A repeating coil, through the condenser, bridged around the 190 special relay, to the ground on the transmitter circuit; which induced the tone test current in the secondary coil of the No. 20 A repeating coil and through the "B" operator's receiver; which causes a high pitched sound, easily recognized as a tone test; thus notifying the "B" operator that the line is out of order. Second; the line may be busy, in which case there is a plug in the jack in another section, which raises the potential of the sleeves of all the jacks connected in multiple with it, so that when the "B" operator touches the sleeve of the jack with the tip of the plug of the assigned trunk, current will flow through the back contact of the 125 A. D. relay, Fig. V., through Point 1, Fig. V., to Point 1, Fig. IV., through the switching key contact, through a winding of the No. 20 A repeating coil, through the winding of the 190 special relay to ground, which operates the 190 special relay and allows current to flow through the primary winding of the No. 24 induction coil, through the 120 ohm non-inductive resistance, through the closed contact of the 190 special relay to ground; which will induce a current in the receiver circuit; which will give the operator a click, thus notifying her that the line is busy. Third; the line may not be out of order or busy, in which case the "B" operator will not receive the tone test or busy test and she will insert the plug in the jack of the line.

The sleeve of all subscribers' lines are grounded through the cut-off relays, as explained in Part 1.; hence, when the "B" board operator inserts the plug of the assigned trunk in the jack of the number called, current will flow through the winding of the 122 W relay, Fig. V., through the winding of the 125 A. D. relay, to ground; which will operate the 125 A. D. relay and may or may not operate the 122 W. relay, depending on which one of the four parties on the four party circuit is to be rung, which will be discussed later. The operation of the 125 A. D. relay allows current to flow through the contact of the 108 E relay,

through the closed contact of the 125 A. D. relay, through the winding of the 122 C. T. relay, to ground, which operates the 122 C. T. relay, which extinguishes the trunk lamp, and allows ringing current to flow through a contact of the 122 W. relay, through a closed contact of the 122 C. T. relay, through the winding of the 114 R. Relay, through a contact of the 122 C. W. relay, to the ring of the plug, over one side of the line, through the bell circuit, to ground; which rings the subscriber's bell, but is not of sufficient quantity to operate the 114 R relay. Before the called subscriber answers, current flows through a closed contact of the 125 A. D. relay, through a closed contact of the 122 C. T. relay, through a contact of the 114 R relay, through a contact of the 122 C. W. relay, through a resistance to ground. When the called subscriber answers the telephone, by taking the receiver off the switch-hook, there is a short on the line, through the subscriber's transmitter, which allows a rush of ringing current to flow through the 114 R relay, and operates it. The current through the closed contact of the 125 A. D. relay and the contact of the 122 C. T. relay will now flow through the winding of the 122 C. W. relay, through the resistance coil to ground; which operates the 122 C. W. relay, which cuts the ringing current off of the line and connects the line through for talking. Current will now flow through a winding of the repeating coil, through the winding of the 118 A relay, through the contacts of the 122 C. W. relay, to the ring of the plug, over one side of the line, through the subscriber's transmitter, over the other side of the line to the tip of the plug, through a closed contact of the 125 A. D. relay, through another winding of the repeating coil to ground; which operates the 118 A relay. The current from the distant office will now flow through the 10,000 ohm and 55-ohm winding of the 108 E relay in parallel, through the closed contact of the 118 A relay, over the other side of the line; which will allow enough current to flow over the line from the connecting cord of the "A" board cord circuit, to operate the connecting supervisory relay and shunt out the supervisory lamp; thus notifying the "A" board operator that the called subscriber answered.

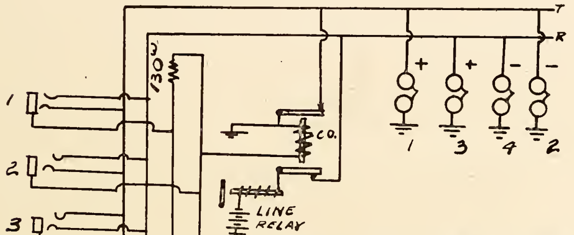
If the called subscriber does not answer immediately and the calling subscriber re-calls the number, the "A" board operator

will say, "I will ring them again." In previous practice and in present practice in some exchanges, it would be necessary for the "A" operator to re-transmit the call over the order wire, and the "B" board operator would re-insert the plug of the trunk in the jack of the called number. Present practice or practice in the near future will be for the "A" operator to re-insert the plug of the connecting card in the jack of the assigned trunk; thus allowing the 108 E relay, Fig. V., and the 122 C. T. relay to become normal and re-operate, so that if by any chance, a firm contact is not obtained after the first operation of the relay a second operation would assure a firm contact.

A feature of the four party nickel circuit which is a mystery to most layman is the fact that four different subscribers are served over one pair of conductors and the bell of any one of the four parties may be rung without interfering with the other three parties on the circuit. The above is made possible by means of the connections made at the bunch block, which is the point at which the line reversals are made and the resistances are connected in the sleeve circuits which, indirectly, selects the polarity of the pulsating generator to be sent out on the line. Fig. VI. is a schematic representation of the connections which simplifies the actual working drawings, so that the principal of operation may be better understood.

In a jack per station office where there is a jack on the "B" board of each subscriber on the four party circuit and one answering jack for the four parties on the "A" board, which is the arrangement in all city exchanges, parties 1 and 2 are reversed at the bunch block, that is, the tips of parties 1 and 2 are connected to the ring of the line and vice versa. The bells on parties 1 and 2 are connected from the tip side of the line to the ground and the bells of parties 3 and 4 are connected from the ring side of the line to the ground. If positive pulsating current is sent over the ring side of the line, it might ring parties 3 and 4 but the bell of party 4 is made inoperative to positive pulsating current by biasing it, that is, there is a spring on the armature of the bell which operates the hammer, holding it in such a position that the initial positive impulse will not pull it away from the gong, hence it will not be able to vibrate and ring the bell. The

bell of party 3 is biased in the opposite direction so that it will operate on positive pulsating current and will be inoperative to negative pulsating current. Similarly the bells of parties 1 and 2 are biased so that the bell of party 3 will operate on positive pulsating current and not operate on negative pulsating current and the bell of party 2 will operate on negative pulsating current and operate on positive pulsating current. Hence, when the plug of the trunk, Fig. V., is inserted in the jack of party 1, Fig. VI.. the 122 W. relay, Fig. V., will not operate due to the 130 ohm



4 PARTY JACK PER STATION
AUTOMATIC RINGING

FIG. VI

resistance, Fig. VI. connected in the sleeve circuit of party 1. Hence, positive pulsating current will flow through the contact of the 122 W. relay, Fig. V., through a closed contact of the 122 C. T. relay, through the winding of the 114 R relay, through a contact of the 122 C. W. to the ring of the plug over the tip of the line, Fig. VI., through the bell of party 1, thus ringing party 1 without interfering with the other parties of the circuit. If the plug of the trunk is inserted in the jack of party 2, the 122 W relay would operate due to the fact that the 130 ohm resistance is not in the sleeve circuit of party 2, and negative pulsating ringing current would flow as in the case of party 1 to the ring of the plug over the tip of the line ,and ring the bell of party 2. Similarly if the plug of the trunk is inserted in party 3 the 122 W relay will not operate and positive pulsating current will flow over the ring side of the line through the bell of party 3 to ground, which would ring party 3. Parties 1 and 3 have the 130 ohm resistance coil in the sleeve circuit. Hence when parties 1 or 3 are rung the 122 W relay is normal and positive pul-

sating current is sent out over the line. When parties 2 or 4 are rung the 122 W relay is operated and negative pulsating current is sent out over the line. We can now understand that when the "B" operator makes the busy test and either parties 1 or 3 is being rung and if there were no high resistance in the busy test circuit the 122 W delay would be operated and parties 2 or 4 would be rung; hence the insertion of the 1600 ohm 190 special relay Fig. IV. in the busy test circuit.

When the called subscribed hangs up his receiver after completing the conversation the short through his transmitter is removed and there is no more current flowing through the 118 A relay, Fig. V., and it becomes normal. The current from the distant office must now flow through the 10,000 ohm winding of the 108 E relay which resistance when conected in the circuit reduces the current sufficiently to allow the 118 A connecting supervisory lamp to light notifying the "A" board operator that the called subscriber has completed the conversation. The calling party likewise hangs up his receiver and the answering supervisory lamp lights. The "A" board operator then takes down the connection, which allows the 108 E relay, Fig. V., to become normal, which allows the 122 C. T. relay to become normal; which allows current to flow through a closed contact of the 125 A. D. relay, through a contact of the 122 C. T. relay, through the trunk lamp to ground; which lights the trunk lamp thus notifying the "B" board operator that the trunk is no longer in use. She then takes down the connection and all relays become normal and the trunk is ready to be used for another call.

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SHOULD ENGINEERS TAKE PART IN POLITICS?

We claim to live under a Democracy, meaning that ours is "a form of government in which the supreme power is retained and directly exercised by the people." With some 20,000,000 voters, more or less, in our nation, the practical difficulties attending a direct exercise of this power leads us into an indirect exercise of it, through a system of delegated authority periodically re-

newed. With a total population in excess of 100,000,000 the franchsie of voting is limited to about one-fifth, comprising free born and naturalized men (and in some cases women) twenty-one years of age and upwards, commonly designated as voters. These voters, constituting the first line of delegates, exercise their franchise in the election of higher delegates whose duty is the direct exercise of supreme power in behalf of, and for the benefit of, the whole nation. On this accepted theory the voters govern the nation and are responsible for its welfare; and the performance or avoidance of the duty thus laid on each voter is the measure and test of his loyalty.

Webster's definition of politics is:

1—"management of a political party; political trickery,"

2—"the science of government."

In a discussion of politics it is well to consider the meaning of the word. Americans are reckless talkers and when one speaks or writes of politics we have to determine his meaning by the setting in which he places the word. Instead of the "science of government" he may mean "political trickery." This has led to confusion in the minds of people, and we commonly think of politics as something disreputable and to be avoided. If we use the first and proper definition, it follows that the knowledge and practice of politics is a function from which the voter has no right to separate himself. Every person who enjoys the protection of our government, though he may not be a citizen in the sense of being native or naturalized, has a legal standing and is interested in and should aid in securing good government. The franchise of voting is desired and valued by all who wish to be good citizens and its privileges cannot be segregated from its duties and responsibilities. If the foregoing statements are true, it follows that every citizen, including engineers, should take part in politics.

I might stop here with the remark that the question at the head of this article is answered in the affirmative, but I only propose that question as leading to others, to wit: do engineers take part in politics, and if not, then why not? It is my opinion that engineers, as a rule, are culpably neglectful of their political duties. I confess myself guilty in this respect, for it is only in recent years that I have taken an interest in public affairs, and have exerted any effort for the promotion of good government.

I don't know how typical my case is, but I fear it is to a considerable extent representative of the political attitude of engineers in general. The attitude of a prominent engineer as expressed in a letter published in the Engineering News of November 23, 1916, may be taken as an extreme example of political conservatism. The writer of the letter evidently desires publicity, and with due acknowledgment to the "News" I insert it herein as a negative reply to the question,

"SHOULD ENGINEERS TAKE PART IN POLITICS?"

"Sir—About ten days before the presidential election, the writer received by the same mail two communications that caused a considerable shock to his professional sensibilities. One of these communications was an appeal signed by 13 prominent members of the American Society of Civil Engineers in New York, urging the writer to join a politico-engineering club and contribute $10 thereto, to promote the election of Judge Hughes as President of the United States. The other was a similar appeal from a prominent member of the society in Chicago, in the interest of President Wilson's candidacy.

"Up to this time the engineering profession, as such, has held itself aloof from the mad and brutal scramble for political 'loaves and fishes' that has been going on all over the country, occupying a more exalted plane and looking with dignified 'neutrality' upon the activities of partisan politics. The great 'American Society' in especial, was regarded by the writer as a serene haven of peace and purity from the polluting influence of politics and politicians. I have often used this expression in talking to younger engineers, that there can be no such thing as a political engineer, because when an engineer becomes a politician he ceases *ipso facto* to be an engineer."

T. G. Dabney.
"Clarksdale, Miss., Nov. 11, 1916.

"(To avoid possible misunderstanding, it may be well to emphasize that the engineering society named did not as a society take any part in political activity. Any action by members of the society of the sort mentioned, must have been taken as individuals.—Editor.)"

I am not one of the engineers mentioned in the letter, but I was aware of their political efforts, and approved their action in

each case, believing in their sincerity and that they were moved by a proper public spirit in soliciting our support for their respective candidates. Mr. Dabney's disgust is in some degree shared by his fellow engineers, but instead of its being a reason for avoiding all connection with politics, it should incite us to work for better political conditions. If engineers and other exalted persons hold themselves aloof from the mad and brutal scramble for political loeves and fishes and look with dignified neutrality upon the activities of partisan politics, they relinquish a sacred right and duty and place government in the hands of voters of lower degree.

Mr. Dabney's letter is not just to the profession. Its members are citizens of common standing who are not privileged to lead a cloistered life to avoid personal contamination. They cannot expect to be turned away from duty for fear of shocks to their professional sensibilities, and they are expected to aid in abating polluting influences in politics, just as they do in water supply, for the good of the community. If the engineer has neglected the common duties of citizenship it is not on account of the selfish reasons stated above. I offer a different reason, which is, that he is so engrossed in the study and practice of the profession, and so imbued with the idea that his work is useful to society, that he over-estimates its importance in comparison with political duties of not so agreeable nature. I think all that is necessary is to lead him into consideration of all the duties of citizenship, and that when he recognizes them he will perform them. It is in the nature of the profession to be thorough and sure, and when engineers take their proper part in politics they will exert a leavening influence in the government of the nation.

I have thus far argued in favor of engineers in the capacity of voters, exercising the privilege and duty of selecting, voting for, and advocating the claims of candidates for public office. It will also tend to purify politics and to promote good government if engineers shall share in the government as public servants, i. e., as office holders. Government, national and local, is divided into three branches, legislative, executive and judicial. Legislative bodies, national, state and municipal are charged with the duties of making laws, preparing budgets for public expenditures, and of appropriating funds for the same. An examination of the proceedings of such bodies will astonish one, not already in-

formed, with the amount of enactments relating to engineering works, both public and private. If we also examine the plans and expenditures of the nation, the states and the municipalities, we will be equally astonished at the great proportion of engineering work which is involved, and at the great cost of the same. Then let us further examine the composition of these legislative bodies and we will find (in this case there is no occaison for astonishment) them composed of professional politicians and of good citizens, and in general of men whose education and vocations have not been such as to give them a practical understanding of engineering works and expenditures. In the membership of these bodies having so much to do with the business of engineering there will be found an almost total lack of professional engineers. No argument is offered that legislatures shall be composed of engineers, but it is obvious that these bodies will be improved by the incorporation in their membership of a sufficient number of engineers to advise on the technical points which must be considered in the adoption of plans, to aid in the preparation of budgets and in organizing for the execution of plans, and to serve on committees which deal with technical matters. It may be claimed that the advice of engineers can be secured by employing them as specialists, which is not to be denied and which may be necessary in any case, but the need of an engineering element in the body itself is so manifest as to require no extended argument. Consequently, engineers should have a place in and share the work of legislative bodies and they should be willing to give this service to the country.

In the executive branches of government, engineers are better recognized and their talents more generally employed. This, however, is a virtue of necessity, for it appears to be the rule that engineers must give way to political favorites in all possible cases. This is especially noticeable in the appointment of commissions and committees. When an engineering department or bureau is recognized as such by the government, there is no escape from the employment of engineers, but they are regarded as workmen to carry out programs which they had little or no part in preparing. The government service is not as attractive to engineers as that of individuals and private corporations, for the reason that the latter affords more scope for initiative and executive work than can be obtained in the former. It would

hardly be proper to discuss this subject without paying a tribute to the honorable record of the U. S. Corps of Engineers, which must be admitted by all who know what they have accomplished. Under the changing conditions of the times there are in addition to the proper work of this Corps, requirements which justify a national Department of Public Works. This is a subject which can only be named in this paper. It has received much attention from a distinguished Civil Engineer, a friend of "The Armour Engineer," Mr. Isham Randolph, and he has set forth his views in an article in this month's issue of the Journal of the Franklin Institute. I commend it to the attention of Engineers. I will only say regarding a National Department of Public Works, into which is gathered the activities of civilian engineers, now scattered through various government departments, that it will promote efficiency and economy in the public service. Similar action in similar lines will produce a like effect in local governments.

I am not prepared to recommend that the judicial branch of government be turned over to the engineers. This does not mean that engineers should not share in the work of the judiciary. Certain courts are much in need of an engineer *"Amicus Curiae,"* which means a disinterested person who advises the court. Cases in which engineers and contractors are interested, and in which the testimony is principally technical, are decided by judges or juries who are not prepared by training or aptitude to pass on technical questions, and proceedings would be simplified and justice forwarded by the aid of an engineer friend of the court. Such an *amicus curiae* is preferably to an array of highly paid engineering experts retained by the contestants to give partisan testimony. A step toward this end can be taken by arranging that expert witnesses shall be employed by the court and paid through the medium of the court, such witnesses having no relation with either party appearing before the court.

The natural objections to submitting technical disputes to courts not versed in technical matters sometimes leads to the employment of engineers as arbitrators. In this case the engineer chosen as arbitrator must possess technical knowledge and a spirit of fairness, and must be as judicial as he can. The best results may be expected when a judge with knowledge of

the law and trained to weigh evidence, is advised in technical matters by a competent *amicus curiae*.

ENGINEERS SHOULD TAKE PART IN POLITICS.

Onward Bates.

The Eagle Macomber Motor Car Co. has placed a car on the market equipped with a special design rotary motor, which is effectively cooled by air instead of water. The motor is being demonstrated at 307 W. Madison St. under the direction of Mr. R. C. Moore and at 70 W. Van Buren under the direction of Mr. J. DuBois. A coridal invitation is extended to all Armour men to visit either of these places and talk over the details of the new motor from a technical standpoint. You will receive special attention by asking for either of the men mentioned above.

The American Association of Engineers will hold a National Convention February 8, 9, and 10 in Chicago at the Hotel La Salle. Work of a promotional nature will constitute the greater part of the program which will be held under the slogan, "FOR THE GOOD OF THE ENGINEER."

A little *tact* will often accomplish results that could not be obtained in any other way than by its use.

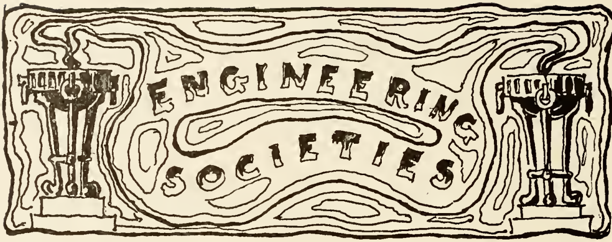
—Waddell.

Nothing gives the general public more confidence in an engineer's ability than to perceive that he is well versed in the cost of all kinds of work.

—Waddell.

Nothing so surely marks a man's secret habits of thought, his real character, as the little tricks of speech which are exhibited when his mind is upon the matter rather than the number of his speech. If his thought be habitually coarse, crude, or brutal, his speech will make the fact manifest at times; and the speech of a moment frequently produces a permanent and vital effect.

—Harrington.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

President ....George M. Fritze
Vice-President ....C. R. Pomeroy
Secretary ....E. W. Haines
Treasurer ....Harold S. White

The meetings that have been held lately by the student branch of the American Society of Mechanical Engineers, in the engineering rooms at Armour Institute have been very interesting to the students. A new idea has been made use of at these meetings in that four students were assigned to speak at each meeting on subjects of their own choosing. As the students were able to choose their own subject, they were able to speak in a more intelligent manner as they chose some subject in which they themselves were interested.

The evening of November 22nd, the men presented very interesting subjects. Messrs. Goodman, Haines, and Huffaker spoke on submarine signaling, the Owen magnetic car, and the manufacture of glass bottles, respectively.

At the next meeting held Dec. 6th, a great deal of business was put out of the way before the speakers of the evening presented their subjects. Mr. King proposed an inspection trip through the Illinois Steel Mills on the following Monday, and it was decided that it be held on that day if permission could be obtained from the professors of the mechanical department.

An illustrated talk was given by Mr. King concerning the ten different types of automobile lubrication. Mr. Morse explained the manufacture of water gas and showed by diagrams the flow of gas through a modern gas manufacturing plant. The subject of construction of stacks was covered very well by Mr. Bretting,

one of our Junior mechanicals. His speech was delivered in a very pleasing manner and if all of the Juniors of the Mechanical class come up to the standard set by him, there is no doubt that the society will have some very interesting meetings next year.

E. W. Haines.

THE FIRE PROTECTION ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY.

President ....A. Corman
Vice-President ....H. B. Maguire
Secretary ....H. W. Puschel
Treasurer ....L. W. Mattern

The third meeting of the year was held Thursday evening, December 7th. It was devoted entirely to a lecture presented to the society by Captain Joseph Mackey of Squad No. 1 of the Chicago Fire Department.

Captain Mackey gave a historic outline of the growth of the fire department of this city, tracing the "C. F. D." from the time, in 1853, when it consisted only of a volunteer department, to the department of the present day, almost immeasurably removed from the former.

After he had completed the "ancient" history of the department, he told us of some incidents which had happened at fires during recent years. Captain Mackey has driven for Chief Horan, Chief Seiferlich, and the present Chief O'Connor; therefore, he did not lack "material" when it came to reciting incidents.

At the end of his talk, he offered to answer any questions the men might like to have explained. It seemed as though every man had been saving up questions, for a large number of very interesting ones were brought up and discussed during the remainder of the evening.

Everybody present enjoyed the talk immensely, and we all wish to see Captain Mackey with us again.

The next meeting will be held Tuesday evening, January 11th. Mr. Fitzhugh Taylor, former Professor of Fire Protection Engineering and now Consulting Engineer, Underwriters' Laboratories, will speak before the society on that evening. Mr. Taylor is, no doubt, one of the leading Fire Protection Engineers in the

world and, therefore, his lecture should be of great interest to every one. Everybody is cordially invited to attend.

H. W. Puschel.

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Chairman........................R. H. Earle
Secretary..................H. A. Kleinman
Treasurer......................W. T. Watt

The third meeting of the year was held Thursday afternoon, November 16th, in the Physics lecture room, at which time two papers were presented. The first, by Mr. L. H. Rosenberg, entitled "Voltage and Current Regulation of Automobile Starting and Lighting Systems" was a discussion of the principles involved in the regulation of these circuits. The second, by Mr. H. A. Kleinman was a discussion of some experiences gained while at work upon an electric clock system.

Thursday afternoon, December 21st, Professor E. H. Freeman gave a very valuable talk on "The Engineer's Personal Equipment." As this is a matter of general interest to engineers and in particular to students of engineer, a summary of his talk will be given here.

An "engineer" is defined as a man who uses the forces and materials of nature to perform some service. The field for service and efforts of the Engineer is classified under the following headings:

Research—investigation, development, invention.

Design—machines, plants, systems, organizations.

Construction—contraction, manufacturing, literature.

Selling—sales engineer, service.

Executive—foremen, managers, etc.

Arbitration—appraisals, expert testimony, patent attorneys, patent examiners.

Legislative—chiefly, at the present time, as advisers to legislative bodies.

Having indicated the field for work, he then proceeded to enumerate the personal qualities deemed necessary or desirable for the fulfillment of positions in the various lines. Using the

results of a canvass of several thousand engineers as a basis, the following table of personal qualities was evolved:

24 % *Character*—integrity, responsibility, resourcefulness, initiative.

15.5% *Judgment*—common sense, scientific attitude, perspective.

16.5% *Efficiency*—thoroughness, accuracy, industry.

15 % *Understanding of Men*—executive ability.

15 % *Knowledge of fundamentals.*

10 % *Technique of practice and business.*

The percentages opposite each quality represent its proportionate value as determined by this canvass. As can be seen the addition of the first four is 75% and these are all non-technical. Only the remaining 25% are strictly technical. Each man was advised to "take stock" of himself, estimate his strong points, and attempt to ascertain which class of work he is best suited for.

The talk was very timely, especially for Seniors, and was enjoyed by all in attendance. The Armour Branch of the A. I. E. E. expresses its thanks to Professor Freeman for this talk.

H. A. Kleinman.

THE CIVIL ENGINERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY.

President..................A. L. Schreiber
Vice-President ....L. E. Starkel
Recording Secretary ....S. N. Miller
Corresponding Secretary.......H. W. Stride
Treasurer ....C. L. Shaw

The third regular meeting of the society was held on Tuesday evening, November 7th. It being election night, it was deemed advisable to employ local talent and consequently we listened to talks by two of the members. These talks, given by Mr. S. N. Miller and Mr. S. W. Newman, were accounts of their summer's work with the C. B. & Q. and the C. M. & St. P. Railways. In spite of the rival attraction of the election to which we later adjourned) they were well attended and greatly enjoyed.

On Tuesday evening, November 21st, we listened to an illustrated talk on "The Aesthetics of Bridge Design," given by Pro-

fessor Wells. This too, proved very interesting and educational, giving us a different light entirely on a subject which otherwise has been presented to us only as a mathematical and structural.

Our next meeting, held on Tuesday evening, Dec. 5th, in the engineering rooms in Chapin Hall, was devoted to hearing a talk by Mr. John C. Bley of the City Bridge Department. He told us of his "Practical Experiences in the Design and Construction of City Bridges." The meeting was well attended and adjourned much later than usual as we had many questions to ask the speaker when he had finished.

The last meeting of the year came on Tuesday evening, Dec. 19th. Our speaker was Mr. Frank Stone, Division Engineer with the C. B. & Q. R. R., whose talk we had been looking forward to for several weeks. He gave us clearly and with many illustrations what he believed to be the qualities necessary to the successful engineer. By the assent of all present this was declared the most interesting and instructive of any meeting so far.

We hope that the success which has attended our meetings this semester will continue undiminished until the close of the school year. *A. L. Schreiber.*

THE CHEMICAL ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY.

President....................A. H. Smith
Vice-President................D. E. Cable
Secretary ....A. G. Fitzner
Treasurer....................O. L. Hailey

On the afternoon of December 15th, 1916, Professor William D. Harkins of the University of Chicago, honored the society by giving a lecture on his most recent work; namely, "The Periodic System." The work is based on a series of experiments which were performed at the Kent Chemical Laboratory of the University of Chicago. The subject was previously presented in a series of thirty-six lectures which Professor Harkins comprehensively summarized for us as follows:

We shall first assume that we have a single crystal of a solid material composed of atoms which are touching each other, the atoms themselves being composed of a positively charged

nucleus surrounded by negatively charged particles or electrons moving at random. The space in which the motion of these electrons is confined is densely charged and the volume of this space determines the size of the atom or the "Atomic Volume" as it is scientifically called.

With these conceptions of structure we are able to account for the physical properties of any material. For clearness of explanation let us assume that we have two materials A and B whose structures show relative space relationships as indicated below:

. . . .
. . . .
. . . .
. . . .
A

.   .   .   .
.   .   .   .
.   .   .   .
.   .   .   .
B

Crystal A is composed of elements of low atomic volume and crystal B is composed of elements of high atomic volume. A represents such materials as carbon, silicon, iron, cobalt, nickle, platinum, iridium, etc. B represents such bodies as are gases at ordinary temperatures such as Helium, Argon, Krypton, etc. A tabulation of the physical properties of the two types A and B shows that the theory is consistent with the facts.

Properties of A

Elements of low atomic vol.
Slightly compressible and very hard
High tensile strength
Low coefficient of expansion
High melting point

Properties of B

Elements of high atomic vol.
Easily compressible
Little or no tensile strength
High coefficient of expansion
Low melting point

The theory up to this point has been dealing mainly with the atom as a whole; that which follows pertains more to the structure of the atom iself. The property of a substance known as the atomic weight connects the number of electrons with their arrangement. The atom itself we have always considered as the fundamental unit of any particular substance, which if further subdivided would be resolved into positively charged nucleous and free negative electrons. Certain experiments with radioactive elements such as Uranum, Radium, Actinium, Thorium, etc., lead us to believe that this theory is wrong, that the heavier atoms are really complex atoms made up of units of simpler and lighter atoms. To cite a particular case let us trace the decomposition series of Uranium. The atomic weight of this element is 238.2, it being the parent substance of the Radium series. The disintegration starts by the shooting off of an Alpha particle (the doubly positively charged nucleous of a helium atom), the change causing the formation of Uranium X_1 (Atomic Wt. 234.2). This gives off a Beta particle and changes into Uranium X_2 without a change of atomic weight, which by the elimination of another Beta particle becomes what is known as Uraniums (Atomic Wt. 230.2). Another Alpha change converts this into Ionium which eliminates another Alpha particle to become Radium. These decompositions may be continued until we obtain Lead from Radium (Pb Ra). The loss of an Alpha particle is accompanied by a decrease of four in atomic weight and a decrease of two in valence and group number. The loss of a Beta particle has the effect of increasing the valence and group number by one, but causes no change in the atomic weight. The experi--ment described points to the existence of a single atom which is eliminated singly or in simple groups or parcels. Before giving this any further consideration it would be well to notice certain regularities which occur in the following table of atomic weights calculated on the hydrogen basis:

Atomic Weight Table On The Hydrogen Basis (H=1).

Element	Atomic Weight	Deviation from nearest even No.	% Deviation from nearest even No.
Hydrogen	1.00	.00	.00
Helium	3.97	.03	.77
Boron	10.92	.08	.77
Carbon	11.91	.09	.77
Nitrogen	13.90	.10	.70
Oxygen	15.88	.12	.77
Fluorine	18.85	.15	.77
Sodium	22.82	.18	.77

Professor Harkins and his assistants have carried out this table for the first twenty-six elements and they have found that the weights so calculated were always slightly less than a whole number and that the average deviation was .77%. These facts Professor Harkins interprets in the following manner. First, that these elements are composed of Hydrogen atoms or some element which weighs slightly less than Hydrogen. If we assume that the fundamental unit is Hydrogen, the loss in weight, approximate .77%, is said to be due to "Packing Effect" due to the magnetic attraction of the positive and negative constituents of the complex atom.

With a similar idea in mind a table in which Hydrogen and Helium were considered the fundamental units was constructed. This table is given on the next page:

Hydrogen determined = 1.0078

Group	0	1	2	3	4	5	6	7	8	
Series 2	He He	Li $He+H_3$	Be 2He+H	B $2He+H_3$	C 3He	N 3He+2H	O 4He	F $4He+H_3$		
Calc. Det.	H_4 4	7 6.94	9 9.1	11 11	12 12	14 14.01	16 16	19 19		
Series 3	Ne 5He	Na $5He+H_3$	Mg 6He	Al $6HE+H_3$	Si 7He	P $7He+H_3$	S 8He	Cl $8He+H_3$		
Calc. Det.	20 20	23 23	24 24.3	27 27.1	28 28.3	31 31.02	32 32.07	35 35.46		
Series 4	A 10He	K $9He+H_3$	Ca 10He	Sc 11He	Ti 12He	V $12He+H_3$	Cr 13He	Mn $13He+H_3$	Fe 14He	Co $14He+H_3$
Calc. Det.	40 39.88	39 39.1	40 40.07	44 44.1	48 48.1	51 51	52 52	55 54.93	56 55.84	59 58.94

Increment from series 2 to series 3 = 4He
Increment from series 3 to series 4 = 5He (Except Ca & K = 4He)
Increment from series 4 to series 5 = 6He

The table shows the composition of the elements on the assumed Hydrogen-Helium basis. The fairly close agreement of the calculated and determined values of the atomic weights shows the possibility of such combinations as are designated in the table.

At this point in the lecture, owing to the lateness of the hour and the large amount of material still to be presented, it was decided that it would be best to adjourn and resume the lecture at some future date. The session ended in a round of applause of heartfelt enthusiasm. Those of us present who were not familiar with Professor Harkins' work were greatly surprised at the startling information presented and we all look forward to his next lecture with anticipation.

A. G. Fitzner.

The extension of the Student Membership of the American Association of Engineers is becoming more and more obvious as shown by the states of the movement at several State Universities.

At the University of Ililnois a temporary organization has already been formed under the name of the Illinois Engineering Club of the American Association of Engineers with the following officers: D. R. Norris, Chairman, Y. A. Pecchia, Secretary and H. E. Fisher, Treasurer. This club will hold a smoker as soon as examinations are over for the purpose of completing the Chapter organization. Professors F. H. Newel and Ira O. Baker and Instructor J. A. DeTurk are faculty members.

At Purdue and Valparaiso Chapters are in formation. The pioneers in at those schools are Professor C. Francis Harding and Dean R. C. Yeoman, respectively.

All departments of the Association in the National Headquarters, 29 S. La Salle St., Chicago, are growing very rapidly, especially the membership department at the average rate of more than one hundred per month. At the present time there is a great demand for good structural engineers.

THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.

Edited by the Publication Committee of the Armour Alumni Association.

F. G. Heuchling F. T. Bangs W. H. Lautz

Communications should be addressed to F. T. Bangs, 608 South Dearborn Street, Chicago, Ill.

THE 1916 MIDWINTER BANQUET.

It is a distinct pleasure to report the 1916 midwinter banquet of the Alumni Association, held December 15 at the Hotel Morrison, because it was the most successful midwinter meeting ever held by the organization. Viewed from every standpoint—entertainment, attendance, and good fellowship—it was a very pleasurable gathering.

The attendance was larger than that of any previous winter meeting, covers being laid for over 140 alumni. Greater representation in all of the different clases made possible a wider renewal of old-time friendships and resulted in a more spirited, enthusiastic and enjoyable gathering.

Before dinner was served Dr. Gunsaulus extended greetings from the Institute, expressed his pleasure of meeting with the alumni and wishes for their success. After dinner Master of Ceremonies Freeman introduced John W. O'Leary, class of 1897,

president of the Chicago Association of Commerce. He was in a reminiscent mood and told of some of the activities at Armour Institute during the first years of its existence, referring, seriously, to the progress made in building up the institution and, humorously, to experiences of the first glee club and to the attractiveness of the co-eds. After an interesting and humorous review of the early days at the institute he finally arrived at his subject, "The Engineering Profession—A Survey," in time to sidestep it and point out in an emphatic manner the growing importance of engineers in the community and the necessity of their recognizing and performing their civic duties, particular stress being laid on the fact that the knowledge and experience of engineers fits them to fill office and decide questions that are now left to inexperienced and bungling politicians who do not possess the required engineering knowledge.

Philip D. Armour, grandson of the founder of Armour Institute, followed and said that he enjoyed his first Association banquet and the opportunity of meeting with the alumni and expressed the hope that he would have the same pleasure every year. The return of his cordiality was evidenced by three cheers and a standing invitation to all Association gatherings.

President Henderson gave an illustrated talk on "Big Creek Hydro-Electric Development," an installation recently completed in California by the Stone & Webster Engineering Corporation, with which he is connected. The slides showed the progress of the construction work on this project, one of the largest water-power developments in the United States, energy from which is transmitted over 200 miles to Los Angeles at the highest voltage—150,000 volts—now used in commercial practice. Mr. Henderson's comments on the pictures made their presentation absorbingly interesting.

The evening's program, despite any previous inference to the contrary, was exceedingly musical, for there were vocal sextettes, quartettes and soloists, and same instrumentally, all furnished by graduates and undergraduates. Everybody joined in doing the song books from cover to cover—so that it can be gathered that the program occupied every minute of the Association's best midwinter meeting, which in itself is a guarantee that it is a forerunner of succeeding meetings of like importance and success.

ALUMNI NOTES.

William Clarkson, '10, is assistant manager and engineer of the Oil City Iron Works, Corsicana, Tex.

Louis Cohen, '01, consulting engineer, 1656, Euclid Street, Washington, D. C., has become a member of the faculty of the George Washington University.

W. O. Collins, '02, for many years chemical engineer with Gulick-Henderson & Company, Chicago, is now operating a stock farm at Califon, N. J.

H. C. Dormitzer, '12, is chemical engineer, Wilson & Company, 4200 Ashland Avenue, Chicago.

C. G. Dreffein, '07, formerly with the Otto Gas Engine Works, New York City, is member of the firm of Flinn & Dreffein Company, 431 South Dearborn Street, Chicago.

L. J. Enzler, '16, is in the engineering department, Goodman Manufacturing Company, 4834 South Halsted Street, Chicago.

B. F. Eyer, '02, formerly general manager of the Marshall County Power & Light Company, Manhattan, Kan., is now secretary and engineer, Finance & Audit Company, 200 Orear-Leslie Bldg., Kansas City, Mo.

R. H. Fash, '05, has become vice-president of the Fort Worth Laboratories, 204½ Houston Street, Fort Worth, Tex. He formerly was chief chemist, Chickasha Cotton Oil Company, Chickasha, Okla.

Millard Gilmore, '07, formerly electrical engineer, the Variety Manufacturing Company, Chicago, is now manager of the Saino Fire Door & Shutter Company, 2025 Elston Avenue, Chicago.

F. R. Goldsmith, '05, who was erecting engineer for the Buckeye Engine Company, Salem, Ohio, has accepted a position as manager of the Canadian branch of the Hotpoint Electric Heating Company, with offices at 25 Brant Street, Toronto, Ont.

Roy Goppelsroeder, '16, is assistant engineer, Underwriters' Laboratories, 207 East Ohio Street, Chicago.

M. Grodsky, '15, is in the designing department, Concrete Steel Products Company, McCormick Building, Chicago.

G. A. Haggander, '07, has been promoted from assistant to bridge engineer of the Chicago, Burlington & Quincy Railway, with offices at 547 West Jackson Boulevard, Chicago.

W. M. Hallstein, '14, is now sales engineer, Illuminating Electric Ventilating Company, 154 Whiting Street, Chicago.

K. P. Gugis, '13, is an attorney-at-law, with offices at 127 North Dearborn Street, Chicago. He is president of the United Lithuanian Societies of Chicago, and president of the Lithuanian National Relief Fund.

W. H. Hamilton, '16, is draftsman with Tallmadge & Watson, 1004 Security Building, Chicago.

Kendrick Harger, '09, is now assistant engineer, Marr, Green & Company, 177 North La Salle Street, Chicago.

J. S. Harvey, '09, is engineer for the Stone & Webster Engineering Corporation. At present he is working in Peoria, Ill.

W. F. Harvey, '05, is now civil engineer in the Chicago Paving Laboratory, with offices at 160 North Fifth Avenue.

G. F. Hayden, '00, is now manager of the Sprinklered Risk Department, Continental Insurance Company, 80 Maiden Lane, New York City.

Carl Heim, '09, who maintains offices at 916-18 Webster Building, 327 7South La Salle Street, Chicago, is president of the United Disposal & Recovery Company of Maine, Interstate Rendering Company of Indiana, and United Disposal & Recovery Company of Michigan; president and treasurer of the United Engineering Company of Illinois, and treasurer of the Montague Iron Works, Montague, Mich.

W. C. Luckow, '16, is working for the General Chemical Company, Hegewisch, Ill.

L. J. McHugh, '16, editor of the *Engineer* last year, is inspector of buildings, Chicago, Burlington & Quincy Railway, Chicago.

F. J. Mack, '12, is associated with the Condron Company, Monadnock Block, Chicago.

Gerald Mahoney, '97, has become connected with the Union Spiral Machine Company, 300 West Kinzie Street, Chicago.

C. H. Marx, '11, is superintendent and engineer, the Nash-Dowdle Company, contractors, 29 South La Salle Street, Chicago.

E. R. Marx, '15, is instrument man, Chicago, Milwaukee & St. Paul Railway. His address is 7 Union Depot, Milwaukee.

J. L. Mayer, '15, is in the engineering department, Mark Manufacturing Company, Zanesville, Ohio.

Frank H. Mayes, '09, is now draftsman with the Illinois Steel Company, South Chicago, Ill.

H. A. MacClyment, '98, has become president of the Mission Auto Electric Company, 450 Main Street, Riverside, Cal.

F. L. Brewer, '15, who went with the Chicago, Burlington & Quincy Railway after graduation, is now engineer with the Stone & Webster Engineering Corporation.

M. A. Buehler, '10, formerly sales agent with the Fort Wayne Works of the General Electric Company at Omaha, Neb., has become power specialist for the Western Electric Company in that city.

W. C. Buttner, '13, is sales engineer, Peoples Gas Light & Coke Company, Chicago.

J. M. Byanskas, '16, is test operator, Armour & Company, Chicago.

Bradley S. Carr, '15, business manager of the *Engineer* during 1915-16, is president of the National Container Company, 140 South Dearborn Street, Chicago.

F. C. Clark, '05, who was employed on electrical construction work during the building of the Panama Canal, and who became superintendent at the Piedro Miguel Locks after the canal was completed, has returned to the States. He is superintendent of the New Castle Construction Company, New Castle, Del.

Fred Clark, '07, formerly division traffic supervisor, Michigan State Telephone Company, is now president of the L. C. Auto Company, 218 West Pearl Stret, Jackson, Mich.

William Dumke, '14, is now with the Electrical Engineers Equipment Company, 7711 Meridian Street, Chicago.

H. A. Durr, '05, is consulting engineer with Schmidt, Garden & Martin, 104 South Michigan Avenue, Chicago.

A. G. Eliel, '14, is with Hall & Ostergren, architects, 19 South La Salle Street, Chicago, Ill.

Philip Eickenburg, '11, is now assistant superintendent of factory, Geo. Cutter Company, South Bend, Ind.

E. S. Echlin, '16, is in the gasoline tractor erection department, J. I. Case Threshing Machine Company, Racine, Wis.

Richard A. Leavell, '10, formerly instructor at Iowa State College, Ames, Iowa, has been made associate professor of mechanical engineering at that institution.

C. R. Leibrandt, '13, is junior engineer in the construction division, City of Chicago, and works at the municipal plant, Thirty-first Street and Sacramento Avenue.

Erwin Edelstein, '16, is rodman, Water Pipe Extension Department, City of Chicago.

M. W. Lee, '99, is now engineering specialist with the Kiebs Pigment & Chemical Company, Newport, Del.

Walter G. Leininger, '06, formerly superintendent of streets, City of Chicago, is now secretary and treasurer, Commonwealth Improvement Company, 179 Washington Street, Chicago.

G. D. Lewis, '12, formerly with the Illinois Steel Works, Gary, Ind., is now in the bridge department, Chicago & North Western Railway, Chicago.

S. E. Holmen, '15, is teaching in the Chicago public schools.

Bertrand G. Jamieson, '97, formerly assistant engineer, Commonwealth Edison Company, Chicago, has been made engineer of inside plant for that company.

B. H. Jarvis, '13, who was with the People Gas Light & Coke Company, has become associated with the Lubricating Metal Company, 2 Rector Street, New York City.

A communication has been received from E. H. Ellett, Sr., of Fairview, Fla., stating that his son, E. H. Ellett, Jr., class of 1907, was shot October 3 in Butte, Mont., the victim of rioters. About 50 of them had been dispersed a block from his hotel a short time before he passed on his way from the office to the hotel. He was wounded twice and, though making a brave fight for life, died six days later. He was associated with the General Electric Company in its Chicago office for some time and recently had been promoted to a position in the Butte office. The tragic circumstances of his death serve to make his loss felt very keenly by his family, to which his Alma Mater extends sympathy and condolence.

H. E. Jedamske, '14, was engaged in work for the United States Coast and Geodetic Survey at Hatteras, N. C., last fall, but has returned to Chicago and is working in the Bridge Department, City of Chicago.

F. C. Johnson, '97, formerly teacher, is now director of the Mechanic Arts Department, North Carolina Agricultural and Technical College, Queensboro, N. C.

O. R. Hupp, '15, is assistant starting engineer, Commonwealth Edison Company, Chicago.

L. B. Jones, '07, has established the L. B. Jones Company, 3310 East Fifteenth Street, Kansas City, Mo.

Arthur Katzinger, '16, is factory superintendent, the Edward Katzinger Company, 120 North Peoria Street, Chicago.

C. F. Kehr, '13, formerly with the Monash-Younker Company, Chicago, is now in the engineering department Jos. F. Ryerson & Son, Chicago.

R. J. Koch, '13, who has been in the engineering department Chicago, Milwaukee & St. Paul Railway since his graduation, recently became sales engineer for the J. E. Rayne Company, Dayton, Ohio.

Jacob Lewis, '15, is employed by A. F. Hassander, architect, Tribune Building, Chicago.

E. O. Langill, '13, is a superintendent transportation staff, Grand Trunk Railway, 920 Merchants Loan & Trust Building, Chicago.

H. A. P. Langstaff, '12, recently accepted the position of assistant designing engineer with Willis L. Adams, consulting engineers, 311 Falls Street, Niagara Falls, N. Y. Formerly he was with the Winnipeg (Can.) Electric Railway Company.

L. W. A. Bunge, '15, recently accepted a position with the Public Service Company of Northern Illinois, 72 West Adams Street, Chicago.

E. R. Burley, '13, formerly with the Old Reliable Truck Company, Chicago, is now superintendent and engineer, Lamson Motor Truck Company, 4646 West Madison Street, Chicago.

E. W. Chamberlain, '09, recently resigned as engineer with O. L. Dean & Company, Chicago, to become engineer for the Gypsum Fireproofing Company, 205 West Monroe Street, Chicago.

L. L. Edlund, '16, is with Gardner & Lindberg, consulting engineers, Marquette Building, Chicago.

R. E. Fischel, '13, formerly electrical engineer with the Union Stockyards & Transit Company, Chicago, is now secretary and treasurer of the U. S. Auto Supply Company, 3845 Wabash Avenue, Chicago.

H. A. Rook, '16, is resident engineer, Illinois State Highway Department, Chicago.

R. H. Robinson, '05, is now efficiency engineer, L. V. Estes, Inc. His address is 1645 West 100th Place, Chicago.

R. P. Pearce, '10, for some time with the Peoples Gas Light & Coke Company, Chicago, is now with the Cornell (Wis.) Wood Products Company.

O. L. Richards, '10, formerly with the Clay Products Company, Chicago, is salesman for Dodge Brothers, 503 La Salle Building, St. Louis, Mo.

L. A. Sanford, '02, formerly with H. Koppers Company, Chicago, is with the Mark Manufacturing Company, Indiana Harbor, Ind.

O. S. Schmiemann, '13, is in the engineering department, S. F. Bowser & Company, Fort Wayne, Ind.

C. R. Schuler, '13, is in the engineering department, Commonwealth Edison Company, Chicago.

M. C. Shedd, '09, formerly superintendent, is now vice-president and manager, Southwestern Iron & Wire Works, El Paso, Tex.

D. E. Willard, '05, is now vice-president of the Decatur Malleable Iron Company, Decatur, Ill.

John Wintercorn, '13, has entered the machine designing department, Jos. T. Ryerson & Son, Chicago.

I. R. Wishnick, '14, is sales engineer, Katzenbach & Bullock Company, Railway Exchange, Chicago.

O. A. Witte, '11 is now chief engineer, American Bureau of Engineering, 1018 South Wabash Avenue, Chicago.

M. Woldenberg, '06, member of the firm of Woldenberg & Schaar, importers of chemical and scientific apparatus, for many years, has become president of A. Daigger & Company, 54 West Kinzie Street, Chicago.

William Wolfson, '16, is with the G. W. Electric Specialty Company, 74th and South Chicago Avenue, Chicago.

ADDRESSES OF ALUMNI.

The recording secretary and treasurer of the Alumni Association are making an effort to bring the list of addresses of graduates up to date. It is quite important that correct mailing addresses be secured for alumni, since the list is used several times a year for sending out notices. Just before the midwinter banquet nearly 1,100 roster cards were sent out, of which about 400 have been returned. Of these over half show that correc-

tions were necessary, and these have helped to make the list more accurate.

Below is published an added list of men whose locations are unknown. Their addresses are wanted, and the Association would like some returns for publishing it. If anyone knows the whereabouts of any of these men let him send a post card to W. H. Lantz, care of Art Institute, Chicago, telling him the correct mailing address.

G. K. Hanai, E. E.............'99
F. W. Twitchell, E. E.......'99
R. C. Martin, E. E.............'00
W. R. Ruegnitz, E. E.........'01
W. T. Charles, Ch. E.........'02
C. T. Brinson, C. E...........'03
Emil F. Nelson, E. E........'03
E. L. Quien, Ch. E...........'03
H. B. Rawson, E. E...........'03
M. J. Knapp, E. E.............'04
R. E. Williams, E. E.........'04
H. J. Ash, E. E...............'05
B. E. Beamer, E. E..........'05
G. W. Fiske, M. E...........'05
Edward McBurney, Jr.......'05
C. R. Snowden, E. E.........'05
E. W. Cutler, E. E...........'06
N. L. Edson, M. E...........'06
Philip Harrington, E. E......'06
E. D. Meyer, E. E...........'06
F. T. Pierce, M. E...........'06
J. N. Schumacher, Ch. E.....'06
A. W. Tyler, E. E............'06
G. M. Heinsen, M. E..........'07
G. S. Laubach, C. E..........'07
David Lurvey, M. E..........'07
C. S. Millard, M. E..........'07
C. J. Nelson, M. E..........'07
E. A. Pratt, M. E.............'07
W. H. Reker, E. E...........'07
Walter Sanders, E. E........'07
Gustav Stanton, M. E.........'07
G. D. Tompkins, C. E........'07
F. C. Collins, E. E...........'08
V. E. Lawrence, E. E........'08
G. G. Meyer, M. E............'08
R. D. Morrison, C. E.........'08
Arnold Pacyna, Ch. E........'08
F. L. Thompson, Ch. E.......'08
J. T. Ahern, F. P. F..........'09
H. C. Anderson, C. E........'09
L. N. Bexten, E. E............'09
T. C. Ford, Ch. E............'09
J. E. Megahy, M. E..........'09
Arthur Perrine, E. E.........'09
E. M. Pinkerton, E. E........'09
F. J. Urson, C. E.............'09
J. M. Valerio, E. E...........'09
A. G. Anderson, C. E........'10
Victor E. Cole, C. E..........'10
F. O. Godfrey, E. E...........'10
T. G. von Gunten, Arch.......'10
W. K. Howenstein, Arch.....'10
E. M. Ruede, E. E............'10
L. T. Zeisler, E. E...........'10
C. E. Beck, M. E.............'11
A. E. Bredlau, C. E...........'11
B. Greengard, Arch ....'11
George B. Hills, C. E........'11
F. H. Griffiths, M. E.........'11
W. G. Tellin, E. E...........'11
L. L. Williams, E. E.........'11
C. W. Collins, C. E..........'12
F. G. Hazen, E. E...........'12
M. Malzen, M. E............'12
H. T. Yoshida, M. E.........'12
C. J. Furay, Arch............'13
D. W. Hamilton, A. ....'13
J. H. Hibler, Ind. Arts.......'13
Charles Kopald, E. E........'13
C. D. Lundblad, Arch........'13
M. D. Wald, M. E............'13
L. M. Jensen, Arch..........'14
C. G. Schmidt, Arch.........'14
M. I. Sevin, C. E............'14
F. M. Valerio, A............'14
Meyer Willens, C. E.........'14
J. C. Wright, A...............'14
C. W. Diemiecke, Ch. E......'15
R. T. Evans, M. E...........'15
T. K. Mieczkowski, E. E......'15
F. E. Price, Ind. Arts........'15
E. T. Taylor, Ind. Arts.......'15
E. S. Youngberg, Ind. Arts...'15

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SYNTHETIC PHENOL MANUFACTURE.

BY C. C. HERITAGE.*

It is not the purpose of this article to discuss the manufacture of phenol synthetically from benzol, in its technical detail, for such a discussion might well be developed into a medium sized volume. We shall therefore consider very briefly: first, the economic conditions which lead to the sudden rise of this industry; second, the raw materials and their availability; and third, the bare fundamental reactions by means of which a hydroxyl radicle is attached to the benzene nucleus in place of a hydrogen atom.

Even the layman is familiar at the present time with the immense growth and intense activity which was occasioned by the war in the chemical industries of the United States. The demand came not only for more of the products which were being made at the time war was declared, but for new products or those which had never progressed further than the experimental stage due in most cases to German competition which could not be met under prevailing conditions of American tariff and labor.

Phenol is produced for the normal market from coal tar by distillation and purification at a cost easily below the fondest hopes of the synthetic manufacturer. The supply of coal tar phenol in times of peace is ample, but with the demand for picric acid in munition works, came the tremendous demand for phenol, which is the initial material in picric manufacture. The phenol market rose rapidly and during the winter of 1915 reached a climax at about $1.50 per pound. Some chemical manufacturers foresaw the coming demand far enough ahead so that they were able to place the synthetic product on the market at just the right time. It is conservative to say that these producers made a profit of no less than ninety cents to one dollar per pound for three or four months. With a plant production of at least 100,000 pounds per month, some estimate may be made of the money earned by these plants at this time.

*Class of 1914

Financiers realizing this condition at once bent every energy to the establishment of other plants, which were barely constructed before the market suffered a heavy decline, as was to be expected. The price of spot phenol fell almost as fast as it had risen, and dropped to a figure at which the average synthetic plant may make but a very modest return on its investment, to the great disappointment of the American capital involved.

The raw materials which are used are: benzol, sulphuric acid, lime or limestone, soda ash, and caustic soda.

The first of these may be purchased as 90's benzol, or as "pure benzol." Both were somewhat difficult to secure, especially pure benzol. Therefore many phenol plants were erected adjacent to a by-product coke plant equipment for benzol recovery. Thus a supply of 90's benzol was guaranteed, that is 90% distilling at 100 deg. centg. This product may contain various impurities such as thiophene, pyridine, carbon disulphide, and unsaturated paraffins; together with a very valuable dydrocarbon, the next higher homologue to benzene, namely toluene.

It was therefore necessary in a good many installations to provide for the proper treatment of 90's benzol, which includes careful washing and fractionation. The washing may be considered a type of sulphonation which is perhaps the most common organic reaction in industrial work. The commoner impurities sulphonate much more readily than benzol itself, especially if care is taken that the temperature does not rise unduly. Ordinarily 97% sulphuric acid is used in quantities varying from 3 or 4% to as much as 15 to 20% by volume on the crude benzol. The latter would of course be an extremely impure material. If much pyridine is present a preliminary wash of 50 deg. Baume[1] sulphuric acid is made to recover the pyridine bases. It is good practice to introduce the acid in several portions, withdrawing the heavy tar after each addition while yet warm enough to flow readily.

The acid wash or washes are generally followed by a warm water wash to clean the benzol of tar and acid; this is followed by a small amount of caustic soda solution to complete the neutralization of traces of acid; and finally the traces of caustic are removed by a second water wash. Agitation is thorough during the acid treatment, but in all other washes, great care must be taken that an emulsion is not formed. When this oc-

curs recourse may be found either in salting out the water, or in holding the benzol at 70 deg. centg. in the still kettle until the emulsion breaks, when the water may be drawn from the bottom of the kettle.

The fractionation of the washed benzol, containing now a minimum of impurities, mainly paraffins, and all the toluol, is accomplished in a rectifying still. This still consists of a kettle, column, dephlegmator, condenser, and receivers. We shall not digress to consider the theory of fractionation, but suffice it to say, that with proper control of "change point," all of the impurities and water and some benzol will be distilled off as "heads" by the time the boiling point of pure benzene is reached. Chemically pure benzene will be distilled inside a range of three-quarters to one degree centigrade, and the residue in the kettle will consist of a mixture of benzol and toluol to be treated separately when sufficient accumulates. This distillation is carried on by means of "indirect" steam. Thus chemically pure benzene has been obtained as the starting point in the phenol process.

It was necessary to purchase two strengths of sulphuric acid, 60 deg. Baume[1] and 97%, unless the plant was designed to concentrate its own 97% acid from 60 deg. Baume[1] acid. The former is used in sulphonating benzene, and its strength must be rigidly maintained at 97. The latter is used in liberating phenol from its sodium salt later in the process, and the nitric acid impurity in this must be kept low so that no colored nitrated bodies are formed during the phenol liberation.

It is not an easy matter to secure a satisfactory lime or limestone. Which is used matters little except that cost and ease of handling is in favor of the latter, while ease of operation favors lime inasmuch as great quantities of carbon dioxide are released in using the powdered stone. Magnesia and silica must be low, for both hinder a proper precipitation and filtration of calcium sulphate.

In regard to soda ash and caustic soda, both were rather difficult to obtain a year or so ago and the market is still strong There is nothing to watch on these materials except the guaranteed content of sodium oxide.

We shall now consider the reactions of the process and very briefly the conditions governing their efficient working.

The sulphonation of benzene and the theoretical combining weights are represented by this equation:

$$\underset{78}{C_6H_6} + \underset{98}{H_2SO_4} \rightarrow \underset{158}{C_6H_5SO_3H} + \underset{18}{H_2O}$$

It is thus seen that theoretically there are needed 1.27 pounds of 100% acid or 1.3 pounds of 97% acid to one pound of benzol. It is difficult, however, to replace the first hydrogen in the benzene ring, and in order to enter any radicle, the reaction must be forced. Therefore it is impossible to sulphonate completely under a ratio of 2.25 acid to benzol. This will produce a spent acid of 75%. Engineers engaged in this industry recommend various strengths of spent acid from 73 to 79. The writer has sulphonated benzene with 101% acid using a ratio of 2. For conservative plant operation, however, taking into account unavoidable variations in acid strength and percentage of water in the washed benzene, a ratio of 2.35 with 97 acid is safe practice.

Agitation within the sulphonater must be intimately effiicient since a liquid of gravity .87 must be intimately mixed with one of 1.84 gravity. The acid is first run to the sulphonator and the benzol is added as rapidly as the temperature and refluxing capacity will permit. Any unsulphonated benzol will of course vaporize when 80 deg. centg. is reached, and from this point on, the capacity of the reflux condenser will govern the time necessary to complete the sulphonation. The writer believes that all the benzol should be added inside the first half hour, which will raise the temperature to about 70 deg. centg. Steam is admitted to the jacket and the temperature carried at 78 deg. centg. for four hours. It is then raised gradually, and finished at any temperature from 85 deg. to 100 deg. centg. There is absolutely no danger of disulphonic bodies at 100 deg. centg.

We now have a sulphonation mixture of approximately 58% benzene sulphonic acid, 32% residual sulphuric acid, 9% water and 1% ferrous sulphate. It is interesting to note at this point that acid hydrogen equivalent to the benzene sulphonic acid has passed to water and is lost as acid. This mixture may either be treated with sodium chloride, or with lime or limestone. The most common procedure is the latter for which the equations are:

$$(1)\quad \underset{316}{2\,C_6H_5SO_3H} + \underset{76}{Ca(OH)_2} \rightarrow \underset{354}{(C_6H_5SO_3)_2Ca} + \underset{36}{2H_2O}$$

$$(2) \qquad \underset{98}{H_2SO_4} + \underset{76}{Ca(OH)_2} \rightarrow \underset{136}{CaSO_4} + \underset{36}{2H_2O}$$

The lime slurry may be added either to the acid mixture or vice-versa. The former is perhaps better in view of possible decomposition of the sulphonic acid, though this procedure necessitates lead lined tanks. Theoretically there are needed .49 pounds of slack lime for the sulphonic acid and .71 pounds for the residual sulphuric, making a total of 1.2 pounds of slacked lime per pound of benzol. In actual practice, to secure a quick neutralization about 1.7 pounds must be used.

This suspension of gypsum and excess lime is filtered hot and the filtrate sent to the conversion of "soda" tank. The cake need not be dried, but after washing down to a content of .75% calcium benzene sulphonate dry basis, is sluiced to the dump.

The conversion of the calcium salt to the soda salt, which is necessary since in the next step it must be fused, is accomplished in two ways. The old and still common method consists in adding soda ash to the hot solution. The equation is

$$\underset{354}{(C_6H_5SO_3)_2Ca} + \underset{106}{Na_2CO_3} \rightarrow \underset{100}{CaCO_3} + \underset{360}{2C_6H_5SO_3Na}$$

Every pound of benzol will therefore require .68 pounds of soda ash and will produce 2.31 pounds of soda salt, commonly termed "silver salt," and .64 pounds of pure calcium carbonate.

The newer method utilizes the waste liquor from the liberation of the fusion solution, the source of which will be explained later. This waste liquor contains sodium sulphate and sodium sulphite. Both salts enter into the conversion producing insoluble calcium sulphate and sulphite. The silver salt thus formed carries considerable more impurities than that resutling from the soda ash conversion. However, these impurities do not seem to be deleterious in the fusion.

The filtrate from the conversion carries from 8 to 10% silver salt and is called "green liquor," or "clear filtrate." It is concentrated to 45% solids in a multiple effect evaporator and further dried to 10% moisture over a drum dryer.

The silver salt is now fused with sodium hydroxide. Up to this point the yield should be practically theoretical. The fusion, however, is the crux of the whole process, and the many variables which enter into it, make it a delicate technical operation. The

reaction is:

$$\underset{180}{C_6H_5SO_3Na} + \underset{80}{2NaOH} \rightarrow \underset{116}{C_6H_5ONa} + \underset{126}{Na_2SO_3} + \underset{18}{H_2O}$$

For every pound of benzol as silver salt, there should be needed 1.03 pounds of sodium hydroxide or 1.07 pounds of commercial 76 test. Or the ratio of caustic to 90% silver salt is theoretically .42. In practice, an excess of caustic is used, generally in the neighborhood of .6, though some plants use a very large excess and recover it as soda ash. Temperatures are in use varying from 310 to 350 °C., and the time neecssary to complete the reaction depends in great part upon the particular set-up, method of heating, heat available, size of pot, and various other factors. It is easy to see how difficult is the control of this unit, and a yield at this point of 85% of the theoretical is considered good.

The hot or liquid melt is now dissolved in water by various methods and the solution containing caustic soda, sodium sulphite, and sodium phenate, is neutralized or "liberated" by the addition of an acid. Various schemes have been put forth from time to time utilizing carbon dioxide or sulphur dioxide gas, which are commendable providing the apparatus is designed with sufficient contact surface. The common method of liberation is by means of 50° or 60° sulphuric in a lead lined vat with good agitation, carried to the liberation of sulphur dioxide. The equations are:

$$(1) \quad \underset{232}{2C_6H_5ONa} + \underset{98}{H_2SO_4} \rightarrow \underset{188}{2C_6H_5OH} + \underset{142}{Na_2SO_4}$$

$$(2) \quad \underset{80}{NaOH} + \underset{98}{H_2SO_4} \rightarrow \underset{142}{Na_2SO_4} + \underset{36}{2H_2O}$$

Expressed per pound of benzol we have 1.27 pounds of sodium phenate requiring .7 pounds of 60° acid producing 1.03 pounds of phenol; and .61 pounds excess caustic requiring .97 pounds of 60° acid, making a total acid consumption of 1.67 pounds per pound of benzol.

On liberation, the crude phenol rises to the top and is separated from the waste liquor. The latter is returned to the system or further treated. The crude phenol is worked up by various methods to remove the dissolved salt, sulphur compounds and water; and is then rectified by distillation. The

first part of this distillation is carried on under atmospheric pressure until the greater part of the water is over, then the entire system is put under as high a vacuum as possible and the charge distilled down to the sludge. Out of a charge of 1200 gallons crude of 15% phenol by volume and 150 gallons of sludge of 60% phenol. This sludge consists of inorganic salts and high boiling diphenyl bodies formed in the fusion.

C. P. phenol must pass rigid tests on color, odor and melting point. On the first there is no difficulty provided the still condenser and receiver are made of the proper materials. In regard to the second, there will always be some slight odor of sulphur compounds which cannot be removed. The melting point should be easily maintained above 40°C, but the writer has yet to see a sample of phenol melt above 40.7°C. using standard thermometers.

We see therefore, that the production of phenol synthetically is a complicated technical process, requiring expert superintendence and constant watching at every stage. The success of phenol manufacturing in this country has added materially to the prestige of the American chemical engineer.

FLOW OF FLUIDS AND FRICTIONAL RESISTANCE IN PIPES.

BY J. M. SPITZGLASS.

With the People's Gas Light and Coke Co., Chicago, Ill.

Part I—Skin Friction.

Part II—Internal Friction; Practical Applications.

PART I—SKIN FRICTION

Consider a given volume of a non-elastic fluid sliding along the inside surface of a pipe with a uniform velocity "V" feet per second. There is a resistance offered to the motion of the fluid by the rubbing surface of the pipe, and a continuous supply of energy is necessary to overcome the effect of this resistance and to maintain the given velocity of the fluid.

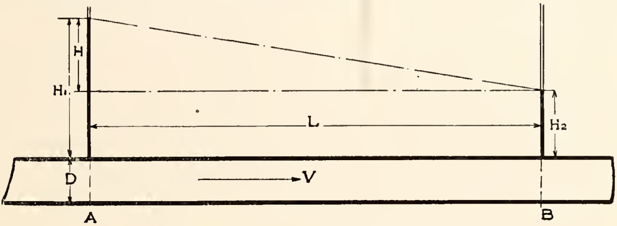
The condition may be represented by Figure 1, where the fluid, having a density "w" pounds per cubic foot is moving with a velocity "V" feet per second, in the pipe of diameter "D" feet. This velocity is maintained over the length "L" feet, by the expenditure of an amount of potential energy, indicated by the drop of head "$H_1 - H_2$" feet, from point "A" to point "B."

Assume that the velocity is uniform over the entire cross-section of the pipe, the same as that of a rigid body; then the loss of potential energy may be considered as caused by the rubbing of the fluid against the walls of the pipe, or by "skin friction" only. By reference to Figure 1 we see that the amount of rubbing surface from A to B is equal to "πDL" square feet; that is to the circumference of the pipe times the length of travel.

The fluid is moving with a velocity V feet per second, and therefore each cubic foot contains $\frac{1}{2} mV^2 = \frac{V^2}{2g} w$ foot pounds of kinetic energy. The velocity pressure equivalent to the impact of the fluid in the direction of the flow is numerically equal to the kinetic energy of one cubic foot of the fluid, or $\frac{V^2}{2g} w$ pounds per square foot. This is apparent from the fact that the kinetic energy of a unit volume of the fluid is equal to the potential energy which was expended in bringing the unit volume to the

*Class 1909. In preparing the article the author was ablv assisted by Mr. J. M. Naiman of Chicago.

given state of motion, and the potential energy in turn is equal to the pressure times the unit volume, or the pressure is equal to the energy contained in a unit volume.



ENERGY LOST = $Hw\frac{\pi}{4}D^2$ FT. LBS.

FRICTION WORK = $f\frac{V^2}{2g}w\pi DL$ FT. LBS.

$f\frac{V^2}{2g}w\pi DL = Hw\frac{\pi}{4}D^2 \therefore f\frac{V^2}{2g} = \frac{H}{L}\cdot\frac{D}{4}$.

Fig. 1. Non-Compressible Fluids.

The frictional resistance offered to the flow at the surface where the fluid comes in contact with the walls of the pipe, is proportional to the velocity pressure of the flow, the same as the sliding friction of a solid is proportional to the weight of the moving solid. The ratio between the resistance per unit rubbing surface caused by friction and the velocity pressure of the flow is denoted by the letter "*f*," called the coefficient of friction, which is analogous to the same term used in the case of friction between two rigid bodies.

Since "*f*" is the ratio of the resistance caused by friction, to the velocity pressure of the flow, the resistance at any given point of the rubbing surface, is equal to $f\frac{V^2}{2g}w$ pounds per square foot. Divide the length of the pipe between A and B into "L" parts of one foot each. Then the rubbing surface in each foot is equal to "πD" square feet. The total resisting force due to friction is equal to

$$f\frac{V^2}{2g}w\,\pi D \text{ pounds,}$$

and the work done in overcoming this resistance over the length of one foot is equal to

$$f\frac{V^2}{2g}w\,\pi D \text{ foot pounds.}$$

It is obvious that the work in foot pounds done in overcoming the frictional resistance over the length of one foot in the pipe must be equal to the potential energy lost in the line over the same length. The loss of potential energy is arrived at as follows:

At point A, the pressure in pounds per square foot of the cross section is "H_1w"; at point B the pressure "H_2w" pounds per square foot. The difference between the two or "Hw" is the pressure in pounds per square foot lost in overcoming friction. This is equal to the amount of energy in foot pounds lost by each cubic foot of the fluid from point "A" to point "B."

Divide the length between A and B into "L" parts of one foot each. We have in each part a volume of fluid equal to "$\frac{\pi}{4} D^2$" cubic feet, and the loss of energy per cubic foot equal to $\frac{\text{“}Hw\text{”}}{L}$ foot pounds; therefore the energy lost in the pipe over the length of one foot is equal to

$$\frac{H}{L} w \frac{\pi}{4} D^2 \text{ foot pounds.}$$

Equating the work done in friction to the loss of energy over each foot of length, we have:

$$f \frac{V^2}{2g} w \pi D = \frac{H}{L} w \frac{\pi D^2}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Removing equals and transposing:

$$f \frac{V^2}{2g} = \frac{H}{L} \times \frac{\frac{\pi D^2}{4}}{\pi D} = \frac{H}{L} \times \frac{D}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

or in units of pressure,

$$f \frac{V^2}{2g} w = \frac{(P_1 - P_2)}{L} \frac{D}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Equations 2 and 3 represent the theoretical relation between friction drop and velocity of fluids in pipes when considering the total drop to be the effect of skin friction only. The physical meaning of the terms is as follows:

"f" is the ratio of the friction drop of pressure per unit rub-

bing surface to the velocity pressure per unit area of the flow. The value of "f" is usually given as an expermiental coefficient, depending upon the roughness of the surface in contact. It will be shown later that the coefficient "f," depends upon the size of the pipe when the effect of internal friction is considered.

$f\frac{V^2}{2g}w$ is the resisting force of friction against the moving fluid. It is equal to the frictional resistance in pounds per square foot of rubbing surface, or to the work in foot pounds done by the fluid in overcoming the resistance of one square foot of rubbing surface.

$f\frac{V^2}{2g}$ is the friction head in feet of the moving fluid. It represents the loss of head for each square foot of rubbing surface in the pipe.

$\frac{H}{L}$ is the loss of head per unit length of the pipe. In liquids $\frac{H}{L}$ is the slope of the line, or the tangent of the angle at which the pipe is laid with the horizontal.

$\frac{(P_1 - P_2)}{L}$ represents the pressure in pounds per square foot lost in friction for each foot length of the pipe.

$\frac{D}{4}$ is the ratio of the loss over one square foot of rubbing surface to the loss over one foot length of the pipe. The factor represents the relation between the *volume* of the fluid conveying the potential energy for overcoming the frictional resistance, and the *surface* of the fluid through which this potential energy is observed by the frictional resistance to the flow. By definition this factor is equal to the cross-sectional area of the fluid divided by the wetted perimeter, and it is usually termed the "Mean Hydraulic Radius" of the flow.

NON-COMPRESSIBLE FLUIDS:

The form of equation 2.

$$f\frac{V^2}{2g} = \frac{H}{L} \times \frac{D}{4}$$

is used more frequently in hydraulics for computing the friction

drop of head in non-compressible fluids, or liquids. The form of equation 3:

$$f\frac{V^2}{2g}w = \frac{(P_1 - P_2)}{L}\frac{D}{4}$$

applies more directly to the friction drop of pressure in the flow of gases and vapors which will be considered later. It should be remembered that these equations always imply the assumption that the total resistance to the flow is the effect of skin friction only. The effect of internal friction upon the flow cannot be neglected, and therefore these and the following equations in which internal friction is not considered can be used only when the coefficient of friction "f" is determined experimentally for each given size of pipe.

Solving equation 2 for the drop of head in terms of velocity, we have

$$H = 4f\frac{L}{D}\frac{V^2}{2g} \quad \ldots\ldots (4)$$

Solving for the velocity in terms of the friction drop, we have

$$V = \left(\frac{2gHD}{4fL}\right)^{1/2} = \left(\frac{2g}{4f}\right)^{1/2}\left(\frac{HD}{L}\right)^{1/2} \quad \ldots\ldots (5)$$

Solving for the quantity of flow, we have

$$Q = \frac{\pi D^2}{4}V = \frac{\pi D^2}{4}\left(\frac{2g}{4f}\right)^{1/2}\left(\frac{HD}{L}\right)^{1/2}$$

or

$$Q = CD^2\left(\frac{HD}{L}\right)^{1/2} = C\left(\frac{HD^5}{L}\right)^{1/2} \quad \ldots\ldots (6)$$

where

$$C = \frac{\pi}{4}\left(\frac{2g}{4f}\right)^{1/2} = 3.15\left(\frac{1}{f}\right)^{1/2} \quad \ldots\ldots (7)$$

Inserting the value of C in equation 6, we have

$$Q = 3.15\left(\frac{1}{f}\right)^{1/2}\left(\frac{HD^5}{L}\right)^{1/2} \quad \ldots\ldots (8)$$

To find the diameter of pipe for a given flow, square both sides of equation 8,

$$Q^2 = (3.15)^2\frac{1}{f}\frac{HD^5}{L},$$

or

$$D^5 = \frac{Q^2Lf}{9.92H}, \text{ and } D = 0.632 \left(\frac{fQ^2L}{H}\right)^{1/5} \quad \ldots\ldots\ldots(9)$$

In these equations:

Q, is the quantity flowing through the pipe in cubic feet per second;

V, is the velocity of the flow in feet per second;

H, L and D are the drop of head, length of pipe, and diameter, all measured in feet;

g, is the acceleration of gravity and equals 32.2 feet per second per second.

f, is the experimental coefficient of friction, for the given size of pipe and roughness of surface.

C, is the coefficient of discharge, as determined by equation 7.

FLOW OF COMPRESSIBLE FLUIDS.

In the case of compressible fluids or gases, we have to consider the increase in volume of a unit weight and consequently the increase in velocity and decrease in density caused by the expansion of the fluid in the pipe during the continuous drop of pressure due to friction.

Considering that the temperature remains practically constant as the pressure drops and the volume increases, the case may be treated as an isothermal expansion during which the density varies directly with the absolute pressure of the fluid.

The condition of the flow may be represented by Figure 2, where a given weight "W" pounds of the fluid is flowing from point "A" to point "B" over the length "L" feet in the pipe of diameter "D" feet having a cross-sectional area "a" square feet, thereby changing the fluid from the initial pressure P_1 and density w_1 to the final pressure P_2 and density w_2. To find the relation of the quantities we proceed as follows:

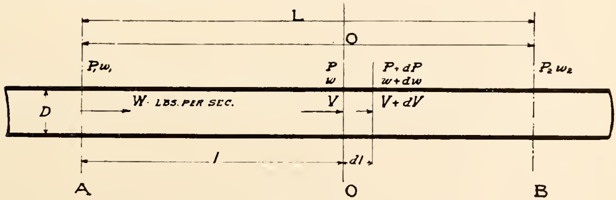


Fig. 2. Compressible Fluids.

Consider the effect of friction over an infinitely small length "dl", at any section "o-o" in the pipe. The fluid passing through the section with the uniform rate of "W" pounds per second, changes from the condition of P, w, and V, to the condition of $P + dP$, $w + dw$, and $V + dV$, the differentials representing the increments over the length "dl" of the pressure, density and velocity of the fluid respectively.

At any cross-section in the pipe $V = \frac{W}{aw}$ and from Boyle's law:

$$\frac{P}{P_1} = \frac{w}{w_1}, \text{ or } w = \frac{w_1}{P_1} P \quad \ldots\ldots (10)$$

From equation 3, we have in general:

$$\frac{(P_1 - P_2)}{L} = \frac{4f}{D} \frac{V^2}{2g} w \quad \ldots\ldots (11)$$

Applying this equation for the small section of the compressible fluid, and using $\frac{W}{aw}$ for V and $\frac{P_1}{w_1 P}$ for $\frac{1}{w}$ we have:

$$-\frac{dP}{dl} = \frac{4f}{2gD} \frac{W^2}{a^2 w} = \frac{4f}{2gD} \frac{W^2 P_1}{a^2 w_1 P} \quad \ldots\ldots (12)$$

(the sign indicates that the change of pressure is negative with respect to length of pipe),
from which

$$-PdP = \frac{4f\ W^2 P}{2gD\ a^2 w_1} dl \quad \ldots\ldots (13).$$

Integrating between the limits of P_1 and P_2

$$-\int_{P_1}^{Ps} PdP = \frac{4f\ W^2 P_1}{2gD\ a^2 w_1} \int_0^L dl \quad \ldots\ldots (14),$$

$$\text{or } \tfrac{1}{2} \left[(P_1)^2 - (P_2)^2 \right] = \frac{4fL}{2gD} \frac{W^2}{a^2} \frac{P_1}{w_1} \quad \ldots\ldots (15)$$

Since $V_1 = \frac{W}{aw_1}$, and $V_2 = \frac{W}{aw_2}$, then $W = aV_1 w_1 = aV_2 w_2$

and

$$\tfrac{1}{2} \left[(P_1)^2 - (P_2)^2 \right] = 4f \frac{L}{D} \frac{(V_1)^2}{2g} P_1 w_1 = 4f \frac{L}{D} \frac{(V_2)^2}{2g} P_2 w_2$$

(16)

Denote the drop $(P_1 - P_2)$ by P_d and the mean pressure $\frac{1}{2}(P_1 + P_2)$ by A, and we have

$$P_d A = 4f \frac{L}{D} P_1 w_1 \frac{(V_1)^2}{2g} = 4f \frac{L}{D} P_2 w_2 \frac{(V_2)^2}{2g}$$

or

$$P_d = 4f \frac{L}{D} \frac{(V_1)^2}{2g} w_1 \frac{P_1}{A} = 4f \frac{L}{D} \frac{(V_2)^2}{2g} w_2 \frac{P_2}{A} \quad \ldots\ldots(17).$$

It is interesting to note that from equation 17 the product of $V^2 w P$ is constant at any section in the pipe.

Solving for the velocity we have

$$V_1 = \left(\frac{2gP_d\,DA}{4f\,w_1 L P_1}\right)^{\frac{1}{2}} = \left(\frac{2g}{4f}\right)^{\frac{1}{2}} \left(\frac{P_d\,D\,A}{w_1\,L\,P_1}\right)^{\frac{1}{2}} \quad \ldots(18)$$

$$V_2 = \left(\frac{2gP_d\,DA}{4fw_2\,PL_2}\right)^{\frac{1}{2}} = \left(\frac{2g}{4f}\right)^{\frac{1}{2}} \left(\frac{P_d\,DA}{w_2 LP_2}\right)^{\frac{1}{2}} \quad \ldots(19)$$

The quantities of the flow corresponding to the velocities V_1 and V_2 are of little practical importance. In the case of vapors the object is to determine the weight of the flow in pounds. In the case of gases, the quantity is usually referred to standard conditions of pressure and temperature, which can be obtained by dividing the weight of the gas by the density at standard conditions. From equation 15, which can also be written

$$P_d A = \frac{4fL}{2g\,D} \frac{W^2}{a^2} \frac{P_1}{w_1}, \text{ we have}$$

$$W = a \left(\frac{2g\,P_d w_1 DA}{4fL\,P_1}\right)^{\frac{1}{2}} = \left(\frac{\pi}{4} D^2\right)\left(\frac{2g}{4f}\right)^{\frac{1}{2}} = \left(\frac{P_d w_1\,DA}{LP_1}\right)^{\frac{1}{2}} =$$

$$C \left(\frac{P_d\,w_1\,D^5\,A}{LP_1}\right)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(20.)$$

where $C = \frac{\pi}{4} \left(\frac{2g}{4f}\right)^{\frac{1}{2}} = 3.15 \left(\frac{1}{f}\right)^{\frac{1}{2}}$

If we denote by w_o the density of the gas at standard conditions, we have for the quality of flow $Q_o = \frac{W}{w_1}$, and from Boyle's Law

$$\frac{w_o}{w_1} = \frac{P_o}{P_1} \frac{14.7 \times 144}{P_1}, \text{ or } \frac{w_1}{P_1} = \frac{w_o}{14.7 \times 144};$$

$$\text{Then } Q_o = \frac{W}{w_o} = C \left(\frac{P_d}{L} \, \frac{w_o}{14.7 \times 144} \, \frac{D^5 A}{w_o} \right)^{1/2}$$

$$= \frac{C}{12 (14.7)^{1/2}} \left(\frac{P_d A D^5}{w_o L} \right)^{1/2} \quad \ldots\ldots\ldots (21)$$

The density of a gas is usually replaced by its specific gravity referred to the density of atmospheric air as unity. The density of air at standard conditions of 60 deg. fahr. and 30 in. is 0.0764 pounds per cubic foot. Denoting the specific gravity of the gas by "S" we have

$$w_o = 0.0764 \text{ S} \quad \ldots\ldots\ldots (22)$$

and equation 21 becomes

$$Q = \frac{C}{12 \, (14.7 \times 0.0764)^{1/2}} \left(\frac{P_d A D^5}{SL} \right)^{1/2} = 0.248 \left(\frac{1}{f} \right)^{1/2} \left(\frac{P_d A D^5}{SL} \right)^{1/2}$$

(23)

In these equations the absolute units of the foot-pound-second system are adhered to.

Q, is the quantity of gas flowing through the pipe in cubic feet per second reduced to standard conditions of 30 in. pressure and 60 deg. fahr. temperature.

V_1 and V_2 are the velocities of the flow in feet per second at the initial and final points of the pipe respectively.

P_d is the pressure drop in pounds per square foot between the two extremes of the pipe.

A, is the mean absolute pressure in the pipe, or one-half of the initial plus the final pressure measured in pounds per square foot.

W, is the weight of the fluid passing through the pipe in one second.

w, is the density of the fluid at the corresponding pressure P in the line.

D, is the diameter of the pipe in feet.

L, is the length of the pipe in feet.

S, is the specific gravity of gas referred to air.

f, is the experimental coefficient determined for the given size of pipe and roughness of surface.

(To be continued.)

RAILWAY PASSENGER CAR HEATING.

BY ELMER W. RIETZ,

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The conditions involved in the heating of railway passenger cars is considerably different from that of house or building heating. Taking for instance a Pullman car, it is put into service and may run for a time on one of the transcontinental railroads where it encounters temperatures from 100 deg. above zero to as low as 40 and 50 deg. below zero. This same car may then be transferred to a run from Chicago to Florida where extreme weather conditions are encountered each trip. For this reason we must have a very flexible heating system, one that can be regulated to suit the various conditions and still simple enough to allow manipulation by the average railroad man. The main point, of course, to bear in mind is that the system must be absolutely non-freezable which requires designing to discharge all water of condensation before freezing can occur.

A railway coach, that does not have the wash water and toilet water pipes to protect, as in the Pullman car, receives even worse treatment and conditions. A railway coach is started out from the terminal under steam, but after the travel gets lighter, it is no longer needed, and is cut off from the train and run on a siding where it is allowed to stand all night without steam; in the morning it is again picked up and placed in the train for return trip, when it must be quickly heated up. If there was any possibility of this car freezing during the night it would cause expensive delays when put into the train in the morning. The two above examples are enough to show the conditions we have to work under.

The first method of heating railway trains was by the use of ordinary wood burning stoves. The objections were: First, the always-present danger of fire in case the train were wrecked; second, the passengers in the immediate vicinity of the stove were too warm while those in the other end of the car were cold, and last, the need of almost constant attention.

The next step was the adoption of the hot water heater, known as the Pullman heater or Baker heater. The heater or stove was placed in the end of the car in a small compartment, lined with metal to reduce the fire danger as much as possible. The

water circulation was usually taken care of by placing four 1¼ in. pipes on each side of the car. This method of heating was far in advance of the old stove because the heat would be uniform throughout the car. The objections were: It would take an hour to get up a fire and a good circulation in the car; at night (the time when a car should be cooled off for sleeping) it would take until almost midnight for the water in the system to cool off, when the car would get too cold, remaining in this condition until morning when the porter would again start up the fire. There was of course the objection of dust in taking out the ashes and putting in the coal.

Next came what we call the straight pressure system. Here the steam was drawn direct from the locomotive and carried back under the train through a train line, composed of 1½ in. pipe connected between cars by rubber hose and quick acting couplers. From this train line, the steam was allowed to enter the car through a 1 in. globe valve where it passed into two 2 in. heating pipes on each side of the car and then out through a steam pipe under the center of the car.

With this arrangement, steam could be had in any car independent of any other, and it was quick acting, taking only a minute to raise the temperature of the radiating pipes to 212 deg. or above, depending upon the pressure of the steam. When the car was too warm, one side could be turned off, if still too warm both sides could be shut off, having no steam on the car at all. The main objection was the large amount of freeze-ups due to carelessness of the train crew, and leaking of the admission valves. The head cars in the train were subject to a pressure of from 50 to 100 lb., while the rear cars might have only 5 or 10 lb. Thus the first cars would be too warm and the last cars too cold.

A large number of the cars equipped with the hot water heaters were fitted up with a steam connection by jacketing the circulation pipes and it was possible to heat these cars with steam instead of fire. The heaters could still be operated by fire in case of a breakdown in the steam supply.

After all the above methods of heating were tried and found wanting, came what we call the vapor system. This system is used on the greater majority of all the railroads in the country

and by the Pullman company. In taking up the examination of the working of the system, I shall start at the locomotive where the steam is generated and carry it through the various conditions it meets in heating the train.

Due to the use by some railroads of the head-end lighting system, there are two conditions involved, namely: the straight vapor system beginning at the engine in trains where the head-end lighting system is not used, and that beginning at the dynamo car where it is used. In the head-end lighting system, the engineer must furnish enough steam to run the dynamo and

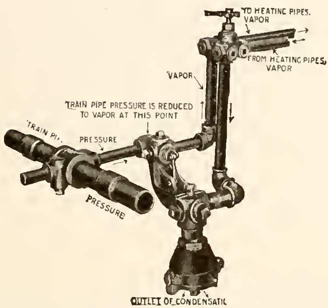


Fig. 1. Arrangement of vapor regulator and connection under car.

heat the train besides. As the dynamo requires a pressure of about 85 lb. of steam to operate, that much must be added to the amount required to heat the train. This is the only difference between the two systems.

When the train has been properly made up and the conductor is ready he goes up to the engineer and asks for steam to heat the train. The amount of steam required varies with the conditions. To determine the pressure required, we count the number of cars in the train and multiply this by five, which gives the pressure required for weather conditions above freezing; if the temperature is about zero we add 10 or 15 lb. to the total mentioned above. For instance, in freezing weather a ten car train should have not less than 50 lb., while in zero weather this same train would have not less than 60 or 65 lb. pressure.

The steam pressure in the locomotive boiler is usually about 200 lb. From the boiler a 1 in. pipe with stop valve, supplies steam to a reducing valve. There is a pressure gauge on each side of the reducing valve, one showing the pressure in the boiler and the other showing the pressure on the train line. From the reducing valve the steam passes through a flexible-metallic connection into the engine tender train line. On all modern cars the train lines are of 2 in. pipe. At the end of the tender is a fitting which clamps the train line to the engine tender holding it in the proper position and still taking care of the expansion. From this fitting the steam passes through the hose and positive lock coupler into the end valve on the next car. The hose connection on this valve is 1½ in. and the train line connection 2 in. The steam then passes through this train pipe (underneath the car, pitching from the center to each end to allow for drain) to the next car and so on throughout the train.

All train pipe valves in the entire train must be open. When steam appears at the rear of the train it is allowed to blow for a few minutes until dry steam shows; the rear valve is then shut and immediately opened a little, for what we call "bleeding." As long as there is steam on the train line there must be an escape of steam at the rear end of the train which will carry off the water of condensation and keep the train line from freezing up. In case this end valve was shut tight water would form and in a few minutes the rear car train line would be frozen shut and the rest of the car would start to freeze. A train is never allowed to leave the terminal until steam is passing through the last car in the train. In case the above mentioned pressure of 5 lb. per car is not enough to carry the steam through to the end (due to faulty hose connections), the conductor calls for more pressure. As long as the train is under steam the rear flagman watches to see that steam is always coming through the rear valve.

When the train approaches a terminal, or when for any reason, steam is to be shut off the train, the rear flagman first opens the end valve wide, allowing the full pressure of the steam to blow through the train for a few minutes, and then signals the engineer to shut off the steam, leaving the rear valve open. By doing this he blows out any water that has been held in the hose and couplers or train line. This leaves a "dry" train line and

one that will never freeze. If this were not done there would be enough water in the train line to freeze up the hose and connections and when the steam was again turned on it would not be able to pass through the train line. With the vapor system the only part of a train that can possibly freeze due to careless handling, is the train line.

Taking up now the actual vapor system, the piping of the cars and its operation:

The vapor system is composed of three units, the vapor regulator, the cut-out steam heat valves and the heating coils or pipe. The Chicago Car Heating Company's vapor regulator is shown in Fig. 1. The purpose of the vapor regulator is to receive steam from the train line at whatever pressure and corresponding temperature it may happen to be at that point, and convert it into steam or vapor under no pressure at all (or atmospheric pressure) at a temperature of 212 deg. before it passes into the heating pipes inside of the car. To be exact, this gives the steam used for heating, a temperature varying from 212 deg. at the point where it enters the inside of the car, to a temperature of about 208 or 210 deg. at the point where it reaches the thermostat to pass off through the outlet of the vapor regulator in the form of condensation.

The vapor regulator depends for its operation on the action of an expansive diaphragm or thermostat located in the bottom of the regulator at the outlet of the heating pipes, where it is acted on by the vapor and heat of escaping condensation. The diaphragm which is shown at E, Fig. 2, consists of a round flat-shaped box, made of spring brass and partly filled with an expansive fluid and hermetically sealed. This fluid will boil at a temperature of about 180 deg. and when heated to a temperature of about 200 to 212 deg. it will exert sufficient internal pressure to cause the swelling out of the flat sides of the diaphragm a distance of about ⅜ in. The expansion of this diaphragm E in the outlet operates the valve S in the inlet steam passage at the upper end of the regulator. Steam from the train pipe passes into the high pressure chamber and through the automatic valve into the low pressure chamber. From there it passes into the heating pipes inside the car through the cut-out valve and back to the outlet chamber of the regulator, where it heats up and expands the thermostatic diaphragm E.

The expansion of the diaphragm tends to close the valve S by raising the rod G and operating the bell crank W, which forces inwardly the stem P and carries the valve S toward a closed position, and as a matter of fact, does close it when live steam at 212 deg. has blown on the diaphragm for a moment. However as soon as the valve S closes, the passage of steam to the diaphragm ceases, and necessarily the temperature of 212 deg., that surrounded the diaphragm when live steam was blowing around it, immediately starts to fall and the diaphragm starts to

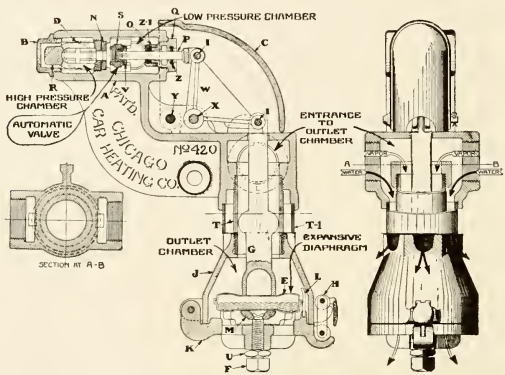


Fig. 2. Details of the Vapor Regulator.

contract. When the temperature has dropped to 200 deg., the liquid has lost some of its expansive force, due to the drop in temperature, and the diaphram starts the contract. This allows the valve S to open slightly and again admit steam to the heating pipes.

Steam will now continue to pass through the heating pipes in sufficient quantities to give a temperature of 200 to 210 deg. at the outlet at the bottom of the regulator. If the temperature at the outlet drops below 200 deg., the diaphragm will contract and open up the valve S which will instantly let in steam from the train line until the outlet gets its 200 deg. of temperature. This must happen in the coldest of weather as well as in warm weather. It gives a positive circulation. The colder the weather the sooner the diaphragm cools and the more steam

enters the radiating pipes. As can be seen, the construction of the diaphragm and regulator is such that with any pressure on the train line of from 5 lb. to 150 lb., it will automatically maintain indefinitely the temperature of approximately 200 deg. at the very outlet of the pipes, under the car where it is placed, which in turn means a temperature of 212 deg. to the pipes inside of the car. The vapor system heats a car at the end of a long train just as warm with 5 lb. pressure as a car at the head of the same train subject to a train line pressure of 125 lb.

The reason that no appreciable pressure is present in the radiating pipes during the short time the train pipe pressure is blowing freely through the automatic valve S before the diaphragm E becomes heated, is because the high pressure passage through the valve disc N is purposely reduced to ⅜ in. in diameter, and as the radiating pipes are usually not smaller than 1½ in., they have therefore about sixteen times the area of the steam passage through the disc N.

When it is considered that the 1½ in. radiating pipes are entirely open at the outlet end and are free and unobstructed through their entire length for the passage of steam entering through the ⅜ in. opening, it will be plain that no appreciable pressure can exist, even during the time taken to get steam to the diaphragm at the outlet. The placing of the thermostat outside of the car does not result in heating the pipes inside the car to a higher temperature in cold weather than in warm weather, because the pipes will necessarily be heated to 212 deg.—no more and no less—in any weather, but the outside location of the thermostat does insure its prompt cooling and consequent opening of the automatic valve and admission of vapor to the heating pipes when the cut-out valve is turned from the closed to the open position. Also the outside location of the thermostat is necessary to get at the very end or outlet of the apparatus where it automatically keeps the outlet hot and prevents the freezing of this coldest and most important point of any car heating apparatus.

The vapor cut-out valve, shown in Fig. 3, controls the admission of heat to the radiating pipes by directing the flow of atmospheric pressure steam. It is usually located on the floor inside of the car at some point easy of access. The valve is provided with a web-shaped plug or wing operating in a four-way valve

body. The plug or wing can be moved a quarter turn only. When the valve is open (Fig. 4), atmospheric pressure steam from the vapor regulator enters one end of the valve and passes through the valve to the heating pipes. After passing through the heating pipes it returns through the other end of the valve to the thermostat in the outlet of the vapor regulator. When

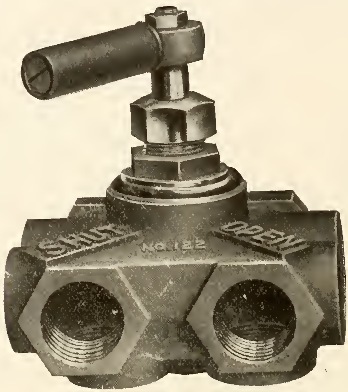
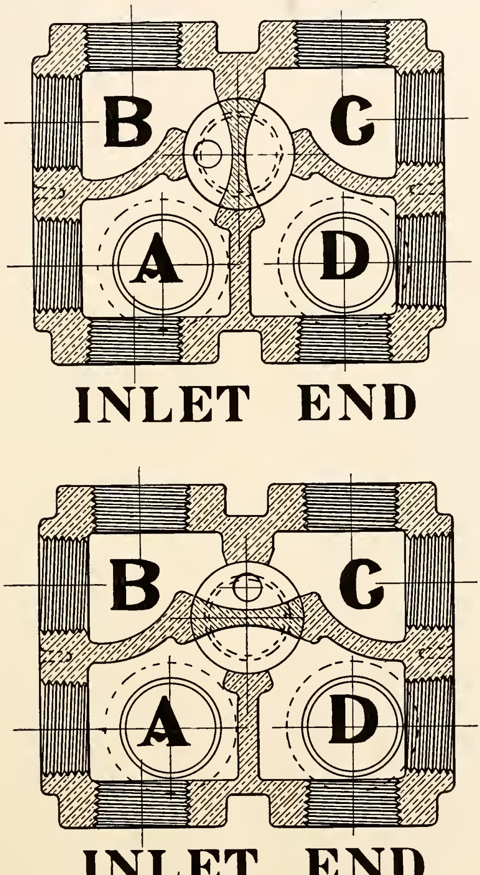


Fig. 3. The Vapor Cut-out Valve for Heat Control.

the valve is closed, as shown in Fig. 5, atmospheric pressure steam passes directly across from one side to the other and to the outlet of the vapor regulator. The cut-out valve is always placed on the atmospheric pressure side of the regulator, *i. e.*, between the regulator and the heating coil, in which position it can never come in contact with the steam under pressure, and, as before stated, its function is merely to direct the flow of vapor or atmospheric pressure steam. It never shuts off the passage of steam to the thermostat. Freezing of drips and drip pipes is absolutely prevented because the steam or vapor is always passing from the automatic valve S clear through to the very outlet of the regulator, regardless of whether it is being passed through the heating coils, or whether it is cut out of the heating coils and "short-circuited" back through the inlet end of the cut-out valve to the outlet of the regulator.

When the valve is open, steam is directed through the radiat-

ing pipes and back to the outlet of the regulator. When the valve is closed steam is "short-circuited" or directed across through the valve, back to the outlet end of the vapor regulator, thus cutting out the steam from passing into the radiating pipes, while keeping it on the thermostat. In the first instance, it gives



Figs. 4 and 5. Open and closed positions of the vapor cut-cut valve.

atmospheric pressure steam throughout the radiation and in the second instance it cuts out or "short-circuits" the steam from the radiation.

In either case the vapor regulator is operating either to fill the radiation with atmospheric pressure steam or to pass the small quantity required to reach from the automatic valve of the regulator through the cut-out valves and connections back to the thermostatic diaphragm in the outlet of the vapor regulator, without going into the radiation. The outlet will automatically get its 200 deg. of temperature from the valve S at all times, provided there is steam on the train line, and the valve S will remain open until the outlet does get it.

When the cut-out valve is moved from the closed or "short-circuiting" position to the open position, what takes place is this: The passage of vapor from the automatic valve S to the diaphragm E through the "short-circuit" passage of the cut-out valve, is instantly stopped and the diaphragm starts to cool and contract at once, opening the inlet valve S. The diaphragm can now obtain the heat necessary to make it operate, only from the vapor that has first passed through the radiating pipes.

Its contraction immediately allows enough steam to pass the valve S to quickly fill the radiating pipes and again heat the diaphragm under the car and make it operate, and the pipes inside of the car will now remain in this condition, *i. e.*, filled with vapor at 212 deg. temperature as long as steam is on the train line, or until the cut-out valve is again turned to the closed or "short-circuited" position.

When the cut-out valve is moved from the open to the closed or "short-circuited" position, what takes place is this: The passage of vapor into the radiating pipes ceases at once and instead, passes direct through the "short-circuit" passage of the cut-out valve to the diaphragm. The steam or vapor that was passing into the radiating pipes, when the cut-out valve was open, now passes direct to the diaphragm, and raises the temperature slightly. This causes it to close the valve S at once, the valve remaining closed a moment until the temperature of the diaphragm drops slightly again, when it allows the valve S to open sufficiently to pass only the very small amount of vapor necessary to reach the diaphragm with sufficient heat to operate it.

When the cut-out valve is left in the open position and the steam turned off the train line the method of piping allows all

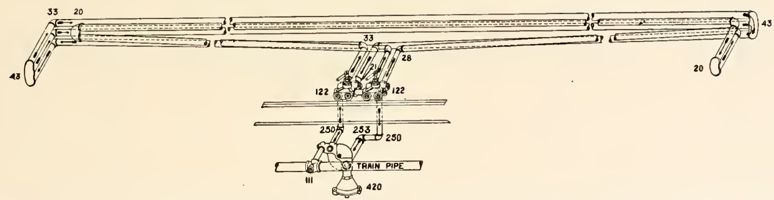


Fig. 6. Arrangement of heating pipes on one side of car for multiple regulator system.

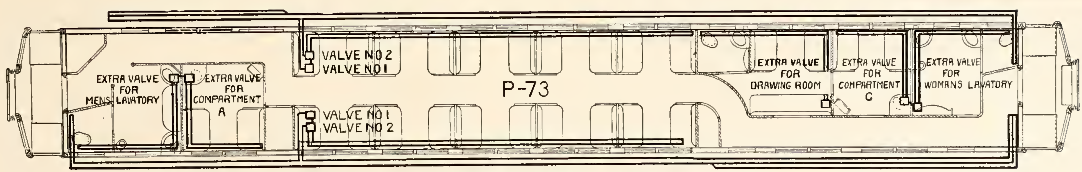


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Fig. 7 Typical arrangement of heating coils and cut-out valves in a standard sleeping car.

water of condensation to escape. When the valve is left in the closed position, however, this is not the case as the web is now cross-wise with the pipe and the water cannot get out the way it came in. To take care of this case we have a special hole in the web and one in the body of the valve. When the valve stem is in the open position this drip hole (size 1/4 in.), is closed or "blanked" by the round flat bottom of the valve stem and is thus inoperative. When the valve stem is in the closed or "short-circuited" position, the drip hole in the valve body is in line with a corresponding hole in the round flat bottom of the valve stem, forming a direct outlet through the drip pipe to the atmosphere and allows all condensation collecting from the heating pipes to escape direct to the ground and also breaks the vacuum that would otherwise exist in the heating pipes when the cut-out valvet is closed. (See Figs. 4 and 5.)

With the old style wooden cars it was permissible to equip a car with a cut-out valve and regulator feeding one coil of three 1½ in. pipes on each side of the car. This allowed the turning off of all the heat, the use of one-half, or the use of all the heat. As there are comparatively few of these cars still in service we will pass them over and take up the heating of the modern steel car.

The only practical and effective method of heating steel cars is to apply sufficient heating surface to properly warm the cars in the most extreme weather, and then so divide this total surface into separate and independently controlled coils or heating units that exact and proper regulations of temperature may be instantly obtained to meet the requirements of less severe weather.

In cars equipped with the multiple regulation system, the arrangement of the heating pipes is either four, five or sometimes six pipes on each side of the car, according to its construction and the severity of the weather it is liable to encounter. So that intermediate regulation may be obtained, the pipes on each side of the car are divided into two coils, each coil being controlled by its own cut-out valve and the two cut-out valves arranged in parallel and attached to one regulator, thus using one regulator and two valves for each side of the car in an ordinary steel coach or chair car. (See Fig. 6.) A separately controlled coil of three pipes and a separately controlled coil of two pipes are used

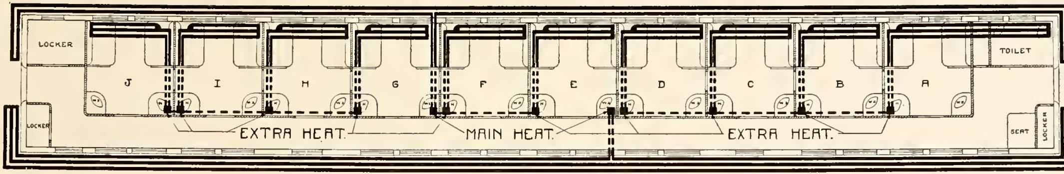

Fig. 8. Arrangement of heating coils and cut-cut valve in a Pullman compartment car.

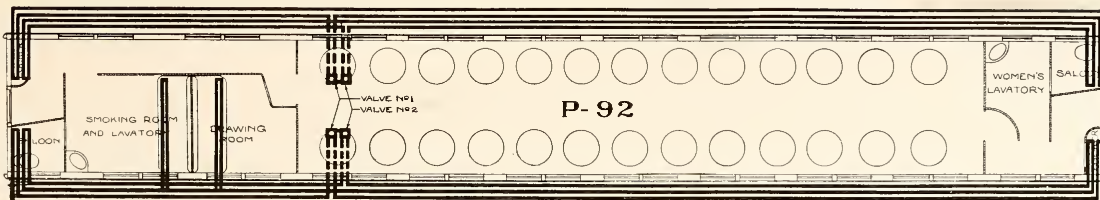

Fig. 9. Arrangement of heating coils and cut-out valves in a Pullman chair car.

on each side of the car. This arrangement of heating surface and cut-out valves permits of the exact regulation of the temperature in the car in the following proportions of the total heating capacity of the system: 20, 30, 40, 50, 60, 70, 80 or 100 per cent.

The above degrees of regulation have been found necessary and very desirable in a steel passenger car because a car of metal construction is particularly susceptible to outside weather conditions, the temperature inside of the car responding very promptly to changes in outside temperature and to outside conditions as to sunlight, darkness, etc. As the cut-out valves are in parallel, the trainmen are enabled to use either the two pipe coil or the three pipe coil on either side separately or together. As before stated all four of the valves in the arrangement are independent of each other and may be used whether any of the others are turned on or not. With a high wind on one side more heat may be turned on that side, the same being the case where one side of the car is in the shade and the other in the sun. Printed direction cards are found in all cars.

The question of heating sleeping cars is more complex than that of a coach. In the sleeping car we have toilet and wash water pipes to protect and at night some parts of the car must have more heat than others. In equipping sleeping cars, the general arrangement of cut-out valves for control of the different coils may be seen by examining Fig. 7.

The cut-out valves for the No. 1 coil (running the full length of the car) and the No. 2 coil (running in the berth section only) are arranged in series; that is, No. 1 coil must be turned on first before steam can enter No. 2 valve. The reason No. 1 and No. 2 valves are arranged in series is that it is desired in cold weather to always have steam on No. 1 coil first, because it runs the entire length of the car and will protect toilet water pipes and hoppers from freezing. If steam could be turned into the short No. 2 coil first, without passing into the long coil No. 1, it would be possible to have the body of the car warm and still freeze up the toilet water pipes and hoppers at the end of the cars. With the arrangement of the No. 1 and No. 2 valves in series as above mentioned this possibility is avoided.

Besides the No. 1 and No. 2 valves above mentioned which

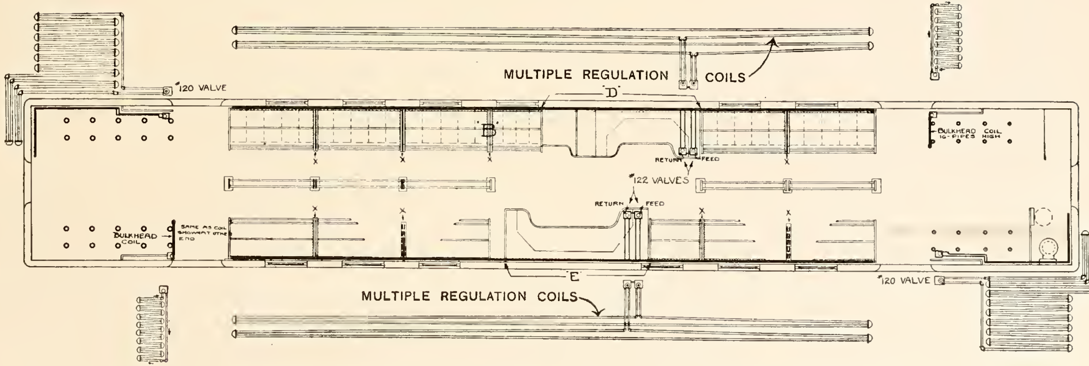

Fig. 10. Arrangement of heating coils and cut-out valves in a Postal car.

are on each side of the car, there are also extra heat valves for separate control of extra heat in the drawing-room compartment, and the ladies' and men's rooms. The cut-out valves for the extra heat controls in the drawing-room and the ladies' dressing room are in parallel; that is, either one may be used independent of the other. The top pipe of the No. 1 is increased to two pipes where it passes through toilet rooms and hallways at the ends of the car.

Table 1. *Number of Feet of Pipe Required Per Foot of Car Length.*

Ratio of Square Feet of Heating Surface to Cubic Feet of Car Volume	Square Feet Heating Surface per Foot of Car Length	1¾ in. Pipe	1½ in. Pipe	2 in. Pipe	Class of Car Construction
1 to 13	9.93	13.60	11.90	9.50	All Steel
1 to 15	5.13	11.80	10.30	8.25	All Steel
1 to 18	4.27	9.82	8.60	6.87	Steel—Wood Finish
1 to 20	3.85	8.85	7.75	6.20	Steel—Wood Finish
1 to 23	3.34	7.70	6.70	5.38	Wood—Steel Underframe
1 to 25	3.08	7.08	6.18	4.95	All Wood

Average Area of Car Cross-section—77 sq. ft.

Bearing the above cautions in mind it is easy to lay out an efficient and practical method of controlling the heat in any type of car, from a coach to a private car. In the latter type of car, we often use as many as 10 cut-out valves to allow for individual control of all staterooms and compartments. From exhaustive tests and observations, the data given in Table 1 has been formulated which it is found will take care of all classes of cars. Figs. 8, 9 and 10 show general arrangements of a few different types of cars.

THE APPLICATION OF SCIENTIFIC MANAGEMENT TO THE PROBLEMS OF THE FACTORY.

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(Continued from January issue.)

SCIENTIFIC SELECTION AND HANDLING OF LABOR.

One of the principal criticisms of industrial re-organization is that since the standard of the workmen is raised, there is a resulting displacement of the less efficient and incompetent workmen. This is not, however, a fair criticism, because in any industry there is a place for every grade of labor. In an unorganized industry, for instance, a high grade workman stops his machine, supplies himself with product from a distance, and after the completion of his operation, pushes the product in a truck to the next operation. Under Scientific Management this labor would be subdivided. The supply of material and the pushing away of the finished product would be cared for by workmen of inferior grade who would find it well within their capacity to accomplish such work, thus allowing the high grade workmen to concentrate upon high grade work. Furthermore, the different operations are analyzed with the aim of picking the proper physical type of labor. For instance, an operation requiring work upon a low machine which cannot for some reason be raised is given to operatives of low stature; operations requiring reaching to considerable height, are given to tall operatives; while the various graduations in arduousness of the task are also properly cared for by utilizing operatives of varying robustness. Thus, each operation is fitted with an operative particularly adapted to that operation, due to his possessing certain adaptable qualities of intelligence, strength or stature. In an industry of any size, it can easily be seen that there is a place for every type and variety of operative.

While the initial selection of labor can be made by the organizer, it cannot be maintained after his departure unless the control of labor, *i. e.* the hiring and to some extent the "firing," be controlled by some central agency. In a large number of modern plants, the Labor Bureau is being instituted and the scientific hiring or selection of labor is rapidly developing into an individual profession. The centralization and specialization of the hiring of labor removes a large burden from the regular

management who would regularly slight this task, as it would interfere with their regular duties. Again the proper selection of workmen requires a more careful investigation as to the ability and antecedents of the prospective operations that can possibly be given by the regular management. Careful records of present, past and, where possible, of prospective employees should also be maintained. The promotion of the workmen in many cases is also under the control of this bureau. The careful selection, control, promotion and prevention of unnecessary "firing" by the Labor Bureau will save any plant a considerable sum of money. The waste in hiring and discharging men is almost incalculable; certain plants have calculated the cost of discharging a man and his replacement, at from $30.00 to $200.00 per individual. This cost includes the necessary clerical labor, the instruction of the new employee, the increased damage to tools, decreased production and spoiled material. Various methods such as long service pensions, mutual insurance benefits and various other forms of so-called "welfare" work have all been tried with the purpose of decreasing hiring and "firing," but to little advantage. Many of the men who have given the subject greatest thought believe that it can only be prevented by an absolutely scientifically conducted central Labor Bureau. Any manager will admit that it is essential to keep the overturn of help as low as possible, and as the express purpose of Scientific Management is to increase the prosperity of the employees as well as the employers, and since, as has been demonstrated, the demand of the workman is simply for more equable means of livelihood, the very application of Scientific Management will have a salutary effect upon excess hiring and "firing." Another cause of labor replacement is the necessity for reducing the payroll when production drops down. Scientific Management demonstrates the possibility of a constant maximum production, thus eliminating this factor also.

COMMON SENSE AS WELL AS TECHNICAL ANALYSIS OF MATERIAL.

A large saving is invariably made in an industrial plant by a careful study of the utility of the materials consumed. The basis for purchasing in various plants vary; some managers buy the cheapest material they can; others the highest priced, with the idea that the higher the quality, the greater the utility;

others simply strike a good medium. In practically all unorganized plants, prejudice for certain brands or trade marks is a guide for purchasing. For instance, the chief engineer recommends a certain packing because the salesman impressed him favorable at some time; the superintendent prefers a certain belt dressing because he has seen it widely advertised, and the manager may insist that raw materials be bought from a personal friend. Other firms base their purchases upon strict technical analysis, allowing their chemists or physicists to guide them by percentages of purity or absence of certain known deterimental substances. In few factories, however, is the medium struck between common sense and technical analysis, *i. e.* absolute utility. The author once spent two months choosing papers for a large textile concern. This concern had previously been purchasing their papers upon the relation of bursting strength in pounds per square inch to the cost per pound. After considerable investigation, the author divided the characteristics of paper into five factors:

A. Bursting strength in pounds per square inch.
B. Moisture test.
    1. Appearance.
    2. Penetration.
C. Weight per unit area.
D. Cost per unit weight.
E. Cost factor $(C \times D)$.

In conjunction with these factors an endeavor was made to apply common sense. A paper for linking packing cases does not require a high bursting strength but necessitates a good moiture test. A paper for wrapping express parcels must have a high bursting strength as well as a good moisture test, and so on, the peculiar properties necessary for the paper used for each purpose was readily ascertained. Previous to the working out of the above cost factor which considers area covered as well as cost per unit weight, five sheets of paper at a certain cost were assumed cheaper than ten sheets of paper weighing the same at 10% greater cost per unit weight, thus utterly ignoring the actual useable quantity of paper. The result of this investigation saved several hundred dollars a year. Investigation of material by the above methods should be carried out for all materials utilized in an industry and the resulting decrease of

material costs will be found gratifying.

TYPES, SPEEDS, BELTING AND UPKEEP OF MACHINERY.

In reorganization work, whenever possible, the original machinery should be utilized. Replacement of machines is a very expensive proposition and will often exhaust the reorganization funds before the reorganization is complete. Such replacements are often of little value as no matter how automatic or efficient a machine is, it will never give its full value unless the controlling organization is well organized and the operatives trained to utilize their machines to the utmost. The original machines can often be remodeled at a comparatively low cost to meet the demands of efficiency altho, of course, in instances where a particularly antiquated machine is found, it should be replaced. In general, however, replacement of machinery should be left until the fruits of the reorganization provide funds for this improved equipment.

The speed of machinery is a much discussed question. Engineers have often found it possible by a few simple changes to operate a machine without detriment to it at a much increased speed over the maximum recommended by the maker. The question of speeds, however, is not entirely one of speeding up. Increased efficiency may often be obtained by decreasing the speed of a machine. The author has seen instances where machines were operated so rapidly that continuous supply of feeding was impossible, the machine making a certain number of operations empty while a slight decrease in speed would have made it possible for the machine to be operated to full capacity thus increasing the product. Once the speeds are set, means must also be provided for the constant checking of the same as there is a tendency for some operatives to lower the speeds, thus attempting to obtain an increase in rates, while other ambitious operatives will increase the speed of the machine beyond the safety limit, or to such an extent that quality is lowered, in order to obtain increased wages.

Another large item in connection with the use of machinery is the problem of belting. Mr. F. W. Taylor and several others have made an intense study of this subject and have published various rules for the maintenance of belting at its greatest efficiency.

Reference to some such set of rules should be made in choosing the variety, size and tension of the belts, and once they are properly installed, a "belt-log" should be maintained in connection with regular prescribed inspection of all belts. This inspection should consist of the application of proper belt dressings at stated intervals and checking of the proper tension. This will result in a saving in power as well as in maintaining the efficiency of the machines.

The general upkeep and repair of machinery is a subject of tremendous importance. The old theory of repairs was to wait until a machine broke down before fixing it. Scientific Management prescribes anticipatory repairs, which may be brought about in the following manner. Whenever a machine breaks down, a careful record should be made of the fact, together with the probable cause and a definite method outlined to prevent future repetition of the trouble. Should this machine break down again a regular inspection for the fault should be instituted at stated intervals, so fixed that should the fault re-occur, it may be caught before it causes trouble. A rigid continuance of this policy with proper co-opeartion from the members of the management actually responsible for the operation of machines, will soon reduce repairs appreciably, and ultimately practically eliminate them. The matter of lubricating should also be standardized and its application properly prescribed. Instead of allowing an oil can to be kicked around a department and utilized by the operative whenever a bearing gets hot, all oiling up should be done by properly instructed employees at stated intervals. Not only will this save motive power and prevent the wearing out of boxes, shafts and journals, but it will often result in a decrease in the amount of lubricants used as they are sometimes carelessly wasted by the regular operatives. The result of the application of the above methods to the machinery of a plant will be a set of highly adaptable and continually efficient equipment. The tremendous loss from break-downs will be eliminated, the depreciation of the machines mitigated to a remarkable extent, and the cost of motive power will be reduced.

FUNCTIONAL FOREMANSHIP.

Traditional industry is generally built up along military lines. The manager shifts responsibility to the superintendent, the superintendent to his assistant, the assistant to the foreman, the

foreman to the gang boss, and the gang boss to the individual workman. There is a continual over-lapping or lack of co-ordination between instructions, control and authority. Responsibility is shifted constantly upon those less capable of assuming it. Scientific Management does away with these conditions. Responsibility is divided between man and management and the foreman becomes an instructor or helper rather than a boss; for instance, where previously production and quality were both assumed by one individual in a department, there are placed a production foreman and a quality foreman, each checking the other and each concentrating upon his individual responsibility. The production foreman assists the men in producing volume while the quality foreman constanly insists that quality be maintained and demonstrates how it may be done. In place of a looker-on, the foreman becomes a fellow workman and just as division of actual labor allows the workman to concentrate upon his particular operation, functional foremen still further subdivide labor by dividing up the responsibility. Should results be unsatisfactory, the functional foreman, not the workmen are held responsible, but it is to the operatives' advantage to have the results favorable (as payment is based upon these results). In place of the old antagonistic difference of attitude between the laborer and the foreman, there exists under functional foremanship absolute unity of purpose between foremen and operatives.

The division of responsibility thru the medium of functional foremanship is F. W. Taylor's method. The Emerson method of obtaining the same result is to divide the management up into "Staff" and "Line" organizations with clearly defined division of responsibility. The fundamental basis of the two methods is the same.

STANDARD INSTRUCTIONS.

In the section on "Standardization" attention was called to the necessity that every detail of process, operation and function be carefully studied and recorded. From these absolute records are evolved standard instructions. For instance, suppose a certain intricate operation occurs frequently in a plant; under traditional methods the superintendent and foreman would necessarily confer as to details and endeavor to carefully instruct the workmen whenever this process occurred, thus entail-

ing considerable overhead expense. Under Scientific Management, the record of each operation after its scientific evolution. is carefully tabulated and filed and is easily located by means of a suggestive symbol. When this operation is about to occur, this standard instruction is taken from the file and sent directly to the workman, who will then have before him, a careful, explicit set of instructions. Under standard instructions, are included all necessary drawings as well as descriptive matter. Often photographs are utilized in connection with such instructions. They are generally maintained in duplicate in order that the loss of a set may be readily duplicated, and their physical form is adapted to the particular conditions under which they will be used; for instance, a drawing and list of instructions going into the oily hands of a mechanic would be covered with a transparent oil—proof cover. The use of such instruction eliminated not only the cost of repeating instructions, but also eliminates errors and tends to greater accuracy and standardization of product. It also eliminates the danger of loss of business details through loss of officials. Standard instructions are the application of standardization to the executive function of the industry.

TASK.

After the study of an industry is completed, including the analysis of processes, the correct rearrangement of equipment thru routing, motion and time study, selection of materials, standardization has exerted itself over all phases of the business, functional foremenship has properly divided the responsibility and the best possible machinery and equipment provided, all is in readiness to set the tasks for each operation. By "task" is meant the standard amount of work to be accomplished under standardized conditions in a standard time by a properly trained workman. While all elements of the previous work do not enter directly into the formation of the task, indirectly every previous phase of work has been more or less incidental to it. For, in the last analysis, the big factor which influences saving is the efficient accomplishment of labor by the workmen, and task is the result toward which all previous work should have been more or less directed in creating conditions properly influencing it, or rendering it possible to better determine it. All the factors which were considered in motion and time study must be carefully reviewed in setting a task. For the accuracy with which

a task is determined is the index of its future success. Into this determination, therefore, must come a consideration for every factor, mechanical, physical or psychical, influencing conditions, equipment and men. The task should by no means be the maxi mum production resulting from steady conscientious labor well within his capacity, both mental and physical.

The form of the task should be such that the workman can readily comprehend it. For instance, to tell a workman that he will receive $2.80 a day if he is 87% efficient is like endeavoring to carry on a conversation with an individual in a language of which he has absolutely no comprehension. To be sure, it is best to avoid expressing a task in terms of the direct relation of money to units since this savors of piece rates, but the general method of payment for the task certainly should be understood by the workmen, because any ignorance or lack of understanding on their part will result in suspicion, and suspicion is the primal breeder of labor troubles. Where a deferential bonus rate is used, the operative should be thoroughly instructed in what is the minimum amount he can accomplish to obtain the advanced rate and a general idea should be given him of what constitutes a fair day's work and what such a fair day will pay. It should also be explained to him that there is absolutely no limit to the amount of work he may do so long as he does good work. The operative should be warned, however, whenever there are indications that he is overworking to the extent of injuring himself physically, and finally he must be absolutely assured that the rate established is a fair rate and that it will under absolutel no conditions ever be reduced unless the operation itself is changed.

BONUS FOR SUCCESS.

The first question a manager usually asks when the setting of tasks is discussed with him is as to how the workmen can be influenced to accomplish this task indefinitely without continual driving. The answer to this is a wage payment method basing the proportion of remuneration upon the proportion of accomplishment. In other words, the greater the efficiency, the greater the payment. Before discussing the various methods of payment, it should be stated that such increase in pay for greater efficiency gives the workman what he most desires—greater wages, or more equable conditions of life, which he has ever

demanded. Frederick W. Taylor says: "Large pay is the greatest desire of a workman and must be given him to keep him contended." Such increase of wages does not mean an increase in labor cost, for using a proper wage payment method based upon efficiency of production will give a lower labor cost as efficiency increases. The cost per piece for a 90% efficient workman in much less than the cost for the unit accomplished by a 70% efficient operative. H. L. Gantt says: "The manager who boasts of the low wages he is paying for his work, would generally find, if he had a reliable cost system, that his costs wer greater than those of his competitors who pay higher wages." Wage payment methods based upon efficiency results give the only known absolute method of raising wages and reducing labor cost without reducing the earnings of or unreasonably driving the workmen. Furthermore, wages based upon efficiency are the surest cure for sabotage, or the tendency upon the part of the workman to avoid doing a full day's work, which is known as "soldiering" in this country, "hanging it out" in England and "Ca-Canae" in Scotland. Sabotage has three principle causes: First, the fallacy that any material increase in the output of each man or each machine in a trade will result in the end in throwing a large number of people out of work; Second, the defective methods of management which make it necessary for the work man to work slowly to avoid cutting down piece rates; Third, unintentional soldiering due to improper methods. Standardization overcomes the third cause and the fallacy which gives rise to the first cause is easily explained by reference to the statistics in such trades as the textile industry, where there have been tremendous gains in that efficiency of production, but still larger increases in the number of people employed. The second reason, which is the most strongly rooted in the minds of workmen since the cutting of piece rates, as was shown above, has been going on for centuries, can only be dispelled by the installation of wage payment methods based upon facts, executed with absolute honesty and rewarded in direct proportion to the resulting efficiency of production.

There are innumerable classifications by which wage payment systems may be classified. One authority classifies wage payment methods as follows:

A. Labor.

B. Piece rate.

C. Premium.

D. Deferential piece rate.

E. Gantt-bonus.

Another says there are but two methods of paying for work; one for the time the man expends on the work and the othe for the amount of work which he does. The first is day work, the second is piece work. Day work and piece work may be further classified as follows:

A. Ordinary day work in which there is no attempt made to keep individual records, every man of the class receiving the same rate.

B. That in which work is carefully put before them so that each man can have continuous work and so that an exact record can be kept of what he does, and his rate of pay be adjusted accordingly.

Piece work may be classified as follows:

A. That at which a price for a job is set from previous records or from the estimates of a foreman who generally considers his duty done when he has set the price. These rates are inaccurate and lead to the cutting of rates when workmen do a large quantity of work, thus preventing them from doing their utmost.

B. Scientifically set and taught piece rates which require; First, scientific investigation of method and time; Second, development of standard methods and setting of maximum time for an efficient workman to accomplish the task.

C. Finding and teaching capable workman to perform the task.

D. Liberal Compensation of workmen,. supply men, instructors, etc.

E. Development of instructors from ranks of workmen, making system progressive.

F. Elimination of all except executive duties from foremen and instituting functional foremen.

This latter form of scientifically instituted piece rate is the type of wage payment advocated by Scientific Management. There are several well established methods of system, a few of which will be briefly described. Some of the most prominent

methods are:

A. Taylor deferential piece rate system.

B. Gantt—bonus system.

C. Towne-Halsey premium system.

D. Emerson Efficiency system, and the Knoeppel modification of the same.

E. Gilbreth three-pay rate with increased rates.

The principal factor of Taylor's deferential system is that there is no quaranteed hourly rate, but a piece rate varying in proportion to efficiency, with high efficiency paid at a higher piece-rate than low efficiency.

The characteristic of the Gantt bonus plan is that there is a guaranteed hourly rate no matter what the efficiency, and a bonus percentage increase over this for accomplishing the task and bettering it. Both Taylor and Gantt plans are based upon accurate scientific time study.

The Towne-Halsey premium system, however, does not utilize past records as standards. There is a guaranteed hourly rate and the workmen receive a premium for performing the task in less time than the standard, varying according to the saving in time. The absence of accurate time study, is a serious hindrance to the progressiveness of this plan.

The Emerson efficiency system guarantees an hourly rate and pays a bonus proportional to the man's actual efficiency. The bonus begins with 10% at 67% and reaches 20% at 100% efficiency. It increases over 100% to 45%. The Knoeppel modification of this allows 20% bonus for 99% efficiency and 25% for 100% efficiency, thus providing a large incentive for attaining full efficiency.

The Gilbreth three-pay rate pays a low rate equivalent to a regular day's pay to the unskilled, a middle rate which is equivalent to about 10% above a regular day's pay to operatives attempting to perform the task by following instructions, and a high rate to operatives actually performing the standard task. For all productions above standard, the use of the deferential is recommended. This method is particularly advantageous with beginners.

The size of the bonus necessary to insure the performance of various standard tasks may be classified as follows: (Expressed as the additional percentage over a regular day's pay:)

A. Little mental effort, light physical effort, 10 to 30%
B. Little mental effort, severe physical effort, 50 to 60%.
C. Mental effort with little physical effort, 70 to 80%.
D. Mental effort with severe physical effort, 80 to 100%.

The mere installation of an improved method of payment does not assure its success. The very installation requires extreme tact and care on the part of the instructor who is generally the one who has set the task. It must be demonstrated to the absolute satisfaction of the operative that the rate is fair and that the task may be accomplished by reasonable effort. The instructor should stay constantly with the workman until he has succeeded in making his bonus. Every lost motion and deviation from standard should be pointed out and explained. Also, proper supply must be insisted on. Many a good task has been given up as impossible just because poor supply at the start has discouraged the workman. The instructor should also follow the progress of the work carefully, informing the workman constantly whether he is ahead or behind time, encouraging him to further effort when behind and congratulating him when ahead. With girls and children such constant attention is imperative and invaluable.

After the rate is fully installed and the workman is earning a good bonus steadily, there are certain practices which must be employed and others which must be avoided. For instance, the payment or notification of amount of bonus earned must be made soon after the work is performed because if the reward is to be effective and stimulating, it must come soon after the work has been done; this applies particularly to young girls and children who must have continual attention both in the form of personal attention and actual reward kept constantly in sight. Another very important point to observe, is to carefully handle all suggestions made regarding the task and bonus by the workmen; each suggestion should be carefully considered, and if feasible, should be adopted and the workman rewarded for the suggestion. But suggestions should not be accepted from workmen until after they have performed the required tasks. The point to be particularly avoided is doubt or suspicion of any kind on the part of the operatives. Another point to be carefully avoided is any reduction in a rate after it is once established unless for some reason the operation be changed. Should a

rate be set "too soft," the opportunity to work under this rate should be utilized as a reward for especially high grade effort, long service, or some other such factor. Also each man's work should be calculated by itself. Gang work should be avoided wherever possible as it tends towards low efficiency. Operatives should also be allowed to leave the plant when the daily task is completed if they wish. But above everything else, the greatest attention and care should be used to gain and maintain their confidence in the validity of the method of payment.

In summary, the problem of setting the task and bonus divides itself into three phases; First, to find out the proper day's task for a man suited to the work; Second, to find the compensation needed to induce such men to do a fair day's work; Third, to plan so that the workman may work continuously and efficiently. Task and bonus properly installed should result in more, better and cheaper work for the employer, and for the workmen,—better wages, increased skill, better habits of work and more pleasure and pride in their work.

PLANNING DEPARTMENT.

The planning department may be divided into five divisions:

1. Scheduling.
2. Materials control.
3. Production control.
4. Time keeping and cost control.
5. Efficiency control.

The planning department centralizes control, eliminating divided responsibility; it assumes many of the duties usually performed by the foremen and some of the duties previously performed by the workmen. The scope of the planning departments such as an information bureau, messenger systems, labor or employment bureau, the control of a mutual insurance association, etc. The Planning Department as described here, is strictly an organization for the direct control of the factory. It is influenced only indirectly by the financial and selling factors of the organization. It exists solely for the factory and its function is to direct the operation of the factory, not only in its daily routine, but also along progressive future lines. In this description of a Planning Department, it is also presupposed that the study, analysis and standardization of all factors of production have taken place and adequate records of the same have

been prepare symbolized and filed for use of the Planning Department.

SCHEDULING.

By scheduling is meant the laying out of the daily work for the entire factory in order to completely utilize, without congestion, every productive factor or unit of the plant. This is accomplished in various ways, one of the simplest being as follows: Knowing the exact capacity of every operative and of every machine in relation to the various operations, a standard task is laid out for each member of the organization for each day. The scheduling is controlled by a sheet upon which spaces are allotted to each hour of the day for each machine and operative. The orders desired first are scheduled first, the time for their accomplishment being noted in the proper spaces on the scheduled sheet by drawing a line through the spaces representing the units of time, noting the factory order number against each line. By means of job cards this information is conveyed to the operatives together with all standard instructions covering the same. Proper standard instruction are also sent to the functional foreman for the adjustment of machinery and the issuance of the proper jigs and tools. Orders are also issued to the store department to deliver necessary materials at certain times and places for application on certain orders. Move orders are made out for directing the movement of all material. In this way the control of the entire processes is centralized in the planning department. This scheduling may be accomplished very economically if the forms used are so designed that they may be filled out by merely checking or drawing lines thru certain spaces. Noting of detailed data should be avoided wherever possible.

At least twelve hours work should be scheduled for each operative for a ten hour day or ten hours for an eight hour day in order that there may be no possibility of his running out of work. Unaccomplished work should be scheduled first for the next day. Proper scheduling will nearly eliminate unproductive time for both workmen and machinery, and result in better deliveries and lower costs.

MATERIALS CONTROL:

In order to make possible the direct scheduling of work, knowledge of available materials and the application of the

same must be accessible in the Planning Department. This is brought about by the installing of a stores system. All stores, materials and supplies are symbolized and means provided for a perpetual inventory of the same within the stores department. A record is kept of receptions and deliveries and the resulting balance, such information being forwarded to the Planning Department. Minimums are also established enabling the Stores department to notify the purchasing department when to order additional stock in time to prevent shortage, and maximums are established to prevent overstocking. An effective stores system should accomplish the following:

A. Prevent all over investment and unnecessary accumulation of materials;

B. Give automatic warning of the approach of the minimum on each item.

C. Furnish adequate records of all receptions and deliveries, showing in every case the invoice number of source received from or receptions, and the factory order number for all deliveries.

The necessary adjuncts of a stores system are:

A. Suggestive symbols and lists of stores;

B. Properly arranged storing facilities;

C. Perpetual balance of each item;

D. Scientifically set minimums and maximums.

PRODUCTION CONTROL.

Means should be provided for constant control of the rate of production expressed as a constant knowledge of how near the plant is up to schedule in a simple visible manner. One of the simplest methods of providing this is some form of control board. A simple form of control board consists of a large wooden tablet or section of wall, providing space for order numbers to be written across the top, and at the lefthand side, a list of prominent division points in the complete operation of the plant. Opposite each division point in the space under each order number should be bored a hole; when an order starts into work a white plug is placed in the first hole under an order number, this line of holes being denoted as "Started." When the order reaches the point in production equivalent to the next hole below, the plug is moved up to this point. This shows the order being handled on schedule time.

Should the order arrive at this point ahead of time, some other colored plug may be inserted, say yellow. Should the order be late, another colored plug should be inserted, say red. A glance by the superintendent and his assistants at this board will tell them, if the majority of plugs are white, that production is up to schedule; should there be a large proportion of yellow plugs, that they are ahead of schedule; should red plugs be in evidence, that they are behind schedule. Also the location of the red plugs will signify at what points congestion is occuring. The maintenance of this board may be very easily accomplished in conjunction with the duties of the timekeeper.

TIME KEEPING AND COST CONTROL.

Within a scientifically instituted Planning Department time keeping is a much different function than under the old method of the weekly payroll, distributed and accumulated to a large extent by guesswork. There are two largely used methods of time keeping which are highly efficient as regards cost control and the actual labor of the function. The first is that each operative stamps the job card mentioned in the section on "Scheduling" when he starts his operation, and again stamps it when he completes the operation, filling out the card with the number of units accomplished and the order number. As these cards come in, the time clerk checks the accuracy of the entries against a schedule showing the size of each order. He also figures each card, bringing forward the amount figured on the last job card, thus figuring the time for each operative thru the latest report, and at the same time notes the amount of production on a production recapitalization sheet with its equivalent cost. As each job is reported, he adjusts the control board mentioned above.

The second method is by means of an annunciator. When an operative starts an operation, he presses a button once which causes his number to appear on the face of the annunciator and sounds a bell once which signifies that he has started the operation. When he finishes, he presses the button twice which rings a bell twice, signifying the finishing of the operation and the annunciator shows his number. The time clerk has a set of job cards arranged in proper sequence according to the day's schedule, and stamps these in proper sequence with

the times of start and finish as the bell and annunciator indicate. The units of production accomplished are reported by a foreman or gang boss by telephone. The cards are figured and posted as in the above method. In either of these two methods, the production control, timekeeping and production and cost records are handled simultaneously. From these records of production and cost, the actual cost may easily be figured and applied to the cost control. The author believes it is unnecessary to go into any description of methods of cost control or its benefits here, as this is a point the value of which practically all modern executives have conceded. A business conducted without reliable cost methods, is a ship without a rudder.

EFFICIENCY CONTROL.

Besides the direct functions outlined above which deal with the daily routine of plant management, the Planning Department must provide for another vitally important factor:—That of progressive control. Means should be provided for constantly improving methods and conditions of production in a factory if it is not to deteriorate. A plant cannot be once organized and maintain its efficiency indefinitely. Every suggestion or idea for improvement should come to the head of the Planning Department who should see that the same methods of analysis and scientific evolution are applied to it as were applied in the preliminary analysis and evolution of the reorganization of the plant before the establishment of the Planning Department, and from these suggestions should be built up new standards for every phase of the work. Furthermore, he should periodically institute investigations along the various lines of the organization with the idea of instituting progressive improvements. In other words, not only should the Planning Department control the factory, but it should constantly improve the methods of control. In this manner will be obtained an efficient, progressive organization.

Finally, some of the principal objections which have been brought up against Scientific Management and the Scientific Management's answers to these objections will be outlined. The following nine objections have been taken from the introduction to a report on the Dartmouth conference:

First: The making of time studies and determinations of tasks are a reflection upon the good faith of labor. Since time studies are made and tasks are set for the management as well as for the operative, this criticism is unfair. The endeavor of the investigator is to objectify the entire organization, both management and operatives, and thus study all. The investigation is applied to every other phase of the industry as well as to labor.

Second: The removal of responsibility from the workman by functional foremanship takes away his interest. This is the last thing that Scientific Management aims to do. It wishes to remove only unreasonable responsibility and place it upon those who are best fitted to bear it. Each workman has the responsibility of doing his work well and accomplishing a legitimate amount, and working in a proper manner is certainly far more stimulating than the old slip shod rule of thumb manner.

Third: Scientific Management through speeding up, tends to wear out workmen. In the first place, an investigation of the plants where Scientific Management has been installed will prove this to be a fallacy, and it should further be borne in mind that a properly set task never speeds the workman beyond his safe capacity, and provides for a legitimate percentage of rest, often enforcing rest periods.

Fourth: It is unapplicable because of the immobility of labor. The result of the installation of Scientific Management is to render labor through better working conditions and greater satisfaction more mobile, therefore the very application of Scientific Management does away with this objection.

Fifth: It inaugurates spying. This is absolutely unfounded. The production and cost control automatically report failure to accomplish the task and standardized inspection automatically reports deterioration of quality. There is no necessity or reason for "spying."

Sixth: The possibility of cutting bonus rates, as piece rates have been cut in the past is dangerous. In the first place, the advocates of Scientific Management always strenuously insist that rates should not be cut and second, since bonus rates are founded upon scientific time study and investigation, not upon

guesswork, resulting in consistent low labor costs, there is absolutely no excuse for cutting such rates.

Seven: The increase of efficiency from Scientific Management will throw large numbers of laborers out of employment. In the first place, the application of Scientific Management must necessarily be slow, thus allowing for natural readjustment. Secondly, the investigation of the statistics of any industry, especially the textile industry, which has been influenced by increase in production due to invention, shows that the increase in workers has been greater than the increase in efficiency, as a result of the placing of the products of the industry in more general use.

Eight: Labor is not allowed to fix the rate of compensation. In regard to this objection, there is absolutely no objection on the part of Scientific Management for labor to assist in setting rates, and in fact, it would welcome such assistance.

Nine: Scientific Management would impair the solidarity of labor. The only factor upon which Scientific Management differs with organized labor, is regarding a standard wage per hour. The influence of labor upon the rates of payment themselves is invited. The only point upon which Scientific Management stands absolute is that payment shall stand proportionate to result, not to time.

Another exceptionally good summary of the criticisms of Scientific Management, is taken from a majority report of the Sub-Committee on Administration of the "American Society of Mechanical Engineers," which is as follows:

"A. The publication of statistics regarding gains made through the use of particular systems, without a frank statement of the degree of inefficiency of the plants before reorganization.

B. The failure to view the plant from the investor's standpoint rather than as a laboratory offering opportunities for interesting and expensive experience.

C. The failure to admit that every application of past solutions to unstudied new and different conditions is an experiment.

D. The waste of time and money on problems that will yield to scientific treatment, but which do not occur often enough to justify such a solution.

E. The undervalueing of effective leadership in management and consequent lack of permanency in results.

F. The overvalue of emasculated "system" leading to a curious non-responsibility on the part of any person for the total results.

G. The frequent assumption that the treatment of the problems of similar plants should be identical.

H. The failure to properly appraise in a growing concern the value of the internal asset of "good-will."

I. The imperfect analysis and appreciation of the human factor in industry, with a consequent failure to reckon patiently with "habit" and "inertia" and a tendency to hasty "substitution," bringing about the breaking up of valuable organization."

The majority of these objections have been fostered thru the lack of experience and training of many of the engineers attempting to apply Scientific Management. Just as there are poorly trained and inadequate men in other professions, so there are in reorganization work. But the true philosophy of Scientific Management must not be judged by these.

Finally, it is asserted that the purposes of Scientific Management as outlined above prove the statement that Scientific Management is an answer to the vital demand of both employer and employee—the age-old demand for more equable conditions of life. As its primal object is greater prosperity for both, and as every phase of its development is a striving towards the satisfaction of this aim, is not Scientific Management one more logical step in the industrial development of the world?

False pride which prevents confession of ignorance is also a fruitful source of error. It takes courage to say, "I do not know," but courage and honesty are among the essential characteristics of a successful engineer.

—Harrington.

The nearest you will ever get to perfection is when you get out of your powers all that there is in them. You will find them stronger the less you dilute them with borrowed force.

—Kerr.

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ENGINEERING AND BUSINESS.

With the consolidation of business enterprises into larger units, it becomes more and more evident that the engineer worthy of that name must be a man who can grasp not only his specific engineering problems, but also the larger, and sometimes more fundamental, questions which are called business activities. The business man of to-day very frequently must acquire technical

knowledge, which will help him in the successful conduct of his business. The engineer, on the other hand, often has to deal with financial and accounting problems, or with problems of investment and of commercial law. For this reason, it is well to call the attention of young engineers to this fact. A number of excellent books have been written covering the different branches of modern business activities. A short survey and classification of these activities is necessary, if one is to have a clear insight into the very complex workings of the modern business world.

Four fundamental activities may be recognized in every business: namely, *producing, marketing, accounting* and *financing.** Producing includes all the processes of turning out goods and getting them ready for delivery. In a trading company, such as a commission house or a retail store, the producing function consists of purchasing the goods that are handled and storing them until they are shipped.

Marketing includes the selling and advertising; the granting of credit; the handling of the sales, correspondence, and the shipping.

The accounting branch of a business prepares financial and statistical records, arranges these records and interprets their meaning and lesson for the future conduct of the business.

Financing comprises the raising and handling of money, the selling of stocks and bonds, the handling of bank loans, making collections, taking discounts, placing insurance, and investing in real estate or securities.

It is evident that courses in engineering colleges cannot deal successfully or exhaustively with so many different phases of business activities. Engineering courses are already overloaded with subjects which treat merely of the engineering problems. The preparation which a student receives in college is to help him in obtaining a position in the *producing* end of the business. He may be satisfied to remain in that department, where he certainly is very valuable as a specialist in construction. Should he aspire to a higher executive position, however, it would be necessary for him to obtain information concerning the other

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* *See Bulletin of the Alexander Hamilton Institute, Astor Place, New York.*

departments; not merely in advertising and selling, but especially in the financing branch. "The most common errors, which are fatal to business enterprises, are often made in connection with financing."

The purpose of this editorial is, therefore, to call the attention of young engineers to the fact that the business end of their work is as important as their constructive activities, if they wish to secure positions with executive powers; and, furthermore, that it must be left to their own initiative to obtain knowledge of experience in these different fields since the College of Engineering has to limit the courses offered to strictly technical and some cultural subjects.

L. C. Monin.

ENGINEERING AND POETRY.

As a rule poetry has no place in a technical paper. And yet I do not feel that I should apologize for making the readers of the Armour Engineer acquainted with a poem that acts like a tonic "when a fella needs a friend." We all get into a tight place once in a while in our lives, where neither engineering skill nor higher mathematics nor any kind of business sagacity will console a tired mind and heart and lift up a courage that has been crushed to the ground.

Therefore, I submit the following poem for the kind consideration of those who need a straightening-up and are beginning to see that a taste of bitter medicine means a healing power which is near.

How Did You Die?

Did you tackle that trouble that came your way
 With a resolute heart and cheerful?
Or hide your face from the light of day
 With a craven soul and fearful?
Oh, a trouble's a ton, or a trouble's an ounce,
 Or a trouble is what you make it,
And it isn't the fact that you're hurt that counts,
 But only how did you take it?

You are beaten to earth? Well, well, what's that?
Come up with a smiling face.
It's nothing against you to fall down flat,
But to lie there—that's disgrace.
The harder you've thrown, why the higher you bounce;
Be proud of your blackened eye!
It isn't the fact that you're licked that counts;
It's how did you fight—and why?

And though you be done to the death, what then?
If you battled the best you could,
If you played your part in the world of men,
Why, The Critic will call it good.
Death comes with a crawl, or comes with a pounce,
And whether he's slow or spry,
It isn't the fact that yu're dead that counts,
But only how did you die?

—*Impertinent Poems by Edmund Vance Cooke.*

Saturday Evening Post, December 6, 1912.

Of course, not one of us expects to be hurt, nor would he acknowledge that he was ever licked. We are all glad that we are alive. Nevertheless, it remains true that whatever befalls us is never as important as *the way we take it.* Our world and our destiny are largely *what we make them.*

L. C. Monin.

HAS INVENTION REACHED ITS LIMIT.

The discoveries and the inventions disclosed and brought forth in the last seventy years have been so wonderful and so numerous that the question may well be asked, has the limit of research been reached or the field of major invention been worked until its soil is exhausted?

These questions apply to every branch of science and the mechanic arts.

The Psalmist says, "the days of our years are three score years and ten and if by reason of strength they be four score years." We will not give the meloncholy ending of that quotation, but only point out that our land is full of men and women whose strength has brought them to four score years.

Within that four score years Morse gave the world a messenger, whose speed is that of the lightning, so swift is it that thought is hardly committed to writing before it is known on other continents.

Bell and Gray labored contemporaneously, but not in concert, and we have the telephone, so essential to our business and social life today that we wonder how that life existed during the years prior to 1876.

In 1877 Edison gave us the phonograph and his name attaches to a progeny of electrical devices which enlighten the world and are hand-maidens in the world's work.

Franklin, with his key attached to the tail of a kite, was feeling for the key hole to the lock, the bolts of which were to be thrown by later scientific locksmiths.

In the realm of chemistry the discoveries have kept pace with the advance in electricity and today, through these discoveries, the wastes, the refuse of other days, are yielding service and wealth to the world.

While chemistry is the handmaiden of Peace, it is a devastator when war makes it a conscript and the gases, which it musters into service, need but the igniting spark to produce desolating explosions.

The healing arts have made advances along the road of succor and comfort to mankind and the name of Pasteur is written in letters of light upon a page illumined by many another name consecrated to the work of preventing disease or alleviating human suffering.

In the mechanic arts a mere enumeration of the inventions of the past sixty years would cover pages of manuscript. Some of the outstanding developments are the steam turbine; the electric generator and dynamo; the automobile; the steel bridges and steel buildings; tunnelling machines; reinforced concrete and scores of other useful inventions which we accept and use as matters of course.

But man has invaded the dominion of the birds in upper air. Bird men are familiar to our gaze. The apocryphal "Darius Green and his flying machine" served as a derisive prophecy of failure for any attempt at aerial navigation, but Tennyson had prophetic vision and in Locksley Hall he sang of the "airy navies grappling in the central blue." How literally has the

poet's vision been seen by mortal eye on the battle fields of Europe; and how his beloved England suffered from aerial raiders. It is only as far back as 1895 that our own Octave Chanute by his gliding experiments, begun in 1875 and carried on amid the near by sand dunes of Indiana, was discovering and recording the scientific principles, the use of which enabled the Wrights, Curtis and others to attain success in aerial endeavor. It was only seventeen years ago that another invasion of the air scored success, for in that year Guglielmo Marconi made a successful demonstration of aerial telegraphy.

The earliest known efforts at submarine navigation were made as far back as 1620. The first success attendant upon that branch of invention was achieved in 1864 when, in Charleston Harbor, a Confederate submarine blew up the U. S. War vessel Housatonic. As Samson perished when he pulled down the temple upon the Philistines, so perished the crew of that submarine. The Holland submarine built in 1875 was the first really successful boat of that type. Later Simon Lake made important improvements. Now the submarine is essentially a weapon. Commerce can never be carried on economically beneath the surface of the sea. How successfully and inhumanly this weapon is now being used is known to all of the world. The arteries of commerce are poisoned by the submarine. Every poison is said to have its antidote. Who will find the antidote for the submarine?

There is a fair field for the investigator and the inventor. Will an Armour man carry off that distinction and do the world that service?

Isham Randolph.

THE RESPONSIBILITY OF THE YOUNG ENGINEER IN ADVANCING HIS PROFESSION.

The many possible ways in which the young engineer is responsible for the advancement of his profession may be listed as follows:

1. Continuing study after graduation.
2. Buying books and collecting data.
3. Post-graduate work at some leading technical school, and obtaining of advanced degrees.
4. Joining technical societies.
5. Systemization of work.

6. Adherence to professional ethics.
7. Setting an ultimate goal to attain.
8. Writing technical papers and books.
9. Publicity of achievement.
10. Helpfulness to others.
11. Becoming a useful citizen, attaining prominence in the community, and keeping abreast of the times.
12. Studying the science of business and salesmanship.

It is now pertinent to make a short comment on each of these twelve *desiderata.*

Continuation of Study.

In respect to continuing study after graduation it may be stated, without any reservation whatsoever, that the man who fails to do so is the man who will not meet with any marked professional success—in fact he is not even likely to attain mediocrity. One can seldom do any piece of engineering work in the best possible manner without first learning how similar work has been done in the past; and to ascertain this he must read and study. One should not only peruse the leading American engineering papers, the Proceedings of one or more technical societies, and the principal new books in his chosen specialty, but also he should study such subjects as economics, engineering law, commerce and trade, and the general progress of science. If he has not already done so at school, he would do well to study the Spanish language; and in case that he has already a command of it, he should read enough Spanish books and papers to prevent himself from becoming rusty, besides practicing the speaking of it on every possible occasion. It is an excellent plan for the young engineer to keep up his mathematics by reviewing what he learned of the subject in his college course; but it will not be worth his while to continue it any farther, unless his work so require, because the mathematics given in any good technical curriculum are generally sufficient for the needs of the practitioner.

Buying Books.

Every practicing engineer should purchase, as fast as they are issued, the various good engineering books, covering the lines in which he is specially interested, no matter how great may be the expense involved. A professional man can get along better without food than without books. He may not

have time to read the entire contents of all that he purchases, but he should at least look them over so as to acquaint himself with their field and be able to refer to them when the necessity for so doing arises. A good serviceable technical library is certainly a most important asset for every practicing engineer.

Post-graduate Course.

Sometimes there comes to a young engineer, after he has been in practice a few years, an opportunity to take a post-graduate course; and he is truly a lucky man who encounters such an opportunity. One year of such instruction as he there receives is worth at least two years of the ordinary technical school course, partially because his practical experience has taught him the value of what he learns, and partially because he is so much better fitted by years and judgment to grasp and absorb the said instruction.

Next best to a post-graduate course is a year or two of teaching technical subjects in a high-grade institution of learning. Such an experience tends to make one exceedingly thorough in his work, especially the mathematical portion thereof. Too much of it, however, is not good; because it would cause an engineer to get out of touch with the practical side of the profession.

Technical Societies.

Every engineering alumnus, just as soon as he receives his diploma, should hasten to join (in the lowest grade, of course) the national technical society most directly connected with his line of work; and if there be a local engineering society in the place where he resides, he should join that also. Through the national society he will come into touch with the great engineering problems of the times, and will make the acquaintance of many of the leaders in the profession, provided that he attends the annual meetings and conventions and, if practicable, the regular bi-monthly meetings also; and through the local society he will become interested in state and municipal questions involving engineering, all of which results are greatly to be desired. He should take as active a part as practicable in the affairs of his technical societies, and should make his services useful and appreciated.

Systemization.

Systemization of one's work enables a man to increase his output thereof and materially to improve its quality. Again, when the time comes for the young engineer to write, his systematically kept records will enable him to produce something worth while.

Ethics.

The young engineer should adhere as closely as he can to the ethics of the profession; and, especially, he should avoid subjecting himself to the slightest suspicion of dishonesty or even sharp practice of any kind. An engineer's reputation is as delicate as a woman's, and if it be once really besmirched, it will be found next to impossible to rehabilitate it. The good things that a man does are often very quickly forgotten, but the bad ones are long remembered.

Ultimate Goal.

If each young engineer were to set for himself a professional goal to attain, and would strive to the limit of his ability to reach it, much good would result to both himself and the engineering profession, even if he should fail finally to arrive at the height of his ambition. If he will always bear in mind that there is plenty of room at the top of the professional tree, and will keep on trying to climb, he will attain results that would be unreachable without the spur of legitimate ambition.

Technical Writing.

Nothing will help a young engineer more than the writing and publishing of good technical papers and books, and nothing, except dishonesty, will injure his reputation more than issuing poor ones. With a year or two after graduation an engineer can properly begin upon a small scale to write technical papers, provided that either he has something new of his own to tell, or that he collects and digests data of real value to the profession that have not previously been adequately compiled; but he should have a number of years of experience before attempting to write a book. The speaker's first book was issued nine years after graduation; and the reason that it was a success may have been primarily the fact that in those days (more than three decades ago) scientific engineering was in its infancy, or, truth to tell, unborn—especially

the branch in which the speaker was then and still is specializing. Some engineers complain that there are too many engineering books on the market. That may be true enough; but, certainly there are not too many good ones, nor can there be, unless they lack in originality or are mere copies from other works. The profession always needs good books for both technical students and busy engineers; because, as long as progress continues, literature can never overtake practice.

Publicity.

In respect to publicity of achievement in engineering, while it is certainly inadvisable for a professional man to make a practice of tooting his own horn, it is perfectly legitimate for him to use proper efforts to have his accomplished works and those of his friends and associates creditably noticed in both technical literature and the daily press. Moreover, such publicity tends to bring the profession of engineer into more prominence. All such notices, however, should be presented in a readable and interesting form which the general public can readily understand; unless, perchance, the subject be one that is altogether too intricate for the layman to comprehend, in which case the notice should appear only in the technical press.

Helpfulness.

One of the greatest possible aids to the advancement of the engineering profession would be the inculcation in all its members of the spirit of mutual helpfulness. The young should go to the old for advice and assistance; but, on the other hand, they should be ready to help their elders in the investigation of problems, the compiling of records, and the systemization of data. Such joint effort and the mutual good will be engendered thereby would be doubly beneficial, in that both the young and the old would be gainers and that their combined work would be serviceable to engineering. Again, the spirit of comradeship involved, if it were to become general, would certainly raise the profession to a higher ethical plane.

Citizenship.

Every young engineer should try to make himself a useful citizen and a credit to the community in which he dwells, as well as merely a successful practitioner. If all engineers were to do their full share of the work in local politics and would take part in the leading questions and problems of the times,

our profession would soon be much more highly appreciated than it is, and, in consequence, the nation would be benefited; because, on account of their technical and business training, engineers, as a body, are capable of more effective effort than the men in most of the other walks of life.

Every engineer, both young and old, should strive hard to keep abreast of the times by at least glancing throcgh the daily papers, by reading such periodicals as the *Review of Reviews,* the *World's Work,* and the *Literary Digest,* and by making himself conversant with the latest important discoveries and developments in the various lines of science and art.

Business.

A young engineer who will recognize that engineering is a business as well as a profession, who will study the principles of salesmanship and the science of general business in its boarder aspects, and who will apply what he thus learns to his engineering practice, will improve greatly his chances for success in his life's work. By thus increasing his personal efficiency he will be doing his share towards increasing also that of the profession as a whole and towards education the public to an adequate conception of its importance.

J. A. L. Waddell.

Some Interesting Phases of Our Transportation Problem.

The transportation question in Chicago is a very important one at present. The traffic in this city has been thoroughly investigated by the Chicago Traction and Subway Commission under the direction of Mr. Henry M. Brinkerhoff, Chief Engineer of the Commission. Mr. Brinkerhoff has carried on similar investigations in other cities and was very capable of handling the Chicago problem, although a very different one. The American Association of Engineers had the extreme good fortune of hearing Mr. Brinkerhoff give some very interesting facts concerning the traffic check and the proposed rapid transit system, at their meeting Thursday evening, March 1, 1917. Some of the points brought out in this lecture are given here because of their interest to the readers of The Armour Engineer.

The object of the traffic check, as brought by Mr. Brinkerhoff, was to find out approximately where the people lived,

where they worked, and how they got between these two points. The check on the "L" system was an easy matter the information being obtained by passing out slips upon which was designated the station at which they were issued and then collecting these slips at the station at which the passenger got off. In this way the people's route of travel on the "L" system was traced. They succeeded in obtaining this information from 93% of the patrons of the "L" system.

The check on the surface lines was not so simple a problem because of the numerous transfer points. There are 445 transfer points on the surface lines with over 4,000 different directions for transferring. The scheme for tracing the route of travel of the people was as follows: One car line, for example Milwaukee Avenue, was taken and the number of people entering and leaving the car at each crossing was found. Special transfers were also issued for one day and these transfers collected and kept separate by the conductors on all lines intersecting Milwaukee Avenue, so that the number transferring from the Milwaukee Avenue line to other lines was found. Then these people were traced down the line upon which they transferred when the traffic check on that particular line was taken. In this way the traffic on each line was found and the number of people transferring determined. Seventy-three per cent (73%) of the patrons of the surface lines were checked. It was found that two million cash fares were collected in Chicago in one day and one million five hundred thousand (1,500,000) transfers issued. Twenty-eight thousand (28,000) people transfer from the surface lines to the "L" system in one day. The commission intends to charge a fee of two cents for such transfers and estimates that this will bring the number of transferees to one hundred thousand (100,000). In time it is their intention to have the charge removed.

As an additional check upon the distribution of the workers, a so-called industrial check was taken at big concerns like The Western Electric Co., Sears-Roebuck & Co., etc., and in the office buildings of the loop district. It worked as follows: The city was divided up into quarter mile sections and the number living in each section determined from the list of employees of the various concerns. In the office buildings, the janitor of the

building co-operated with the commission and obtained the addresses of all occupants of the building as near as possible. The distribution worked out by this method checked very closely with that obtained by the traffic check. The following is an interesting example, related by Mr. Brinkerhoff, of the remarkable check in the two methods: The industrial check showed that there were twenty-one people working at The Western Electric Co. who lived within walking distance of the Woodlawn station of the South Side "L." The traffic check showed that twenty-two people boarded the "L" at this station in the morning rush hours and got off at stations in the immediate vicinity of The Western Electric plant.

All the data obtained gave the commission a fundamental working basis for finding the congested districts of the city and to devise a means for relieving this congestion. Mr. Brinkerhoff showed slides of the numerous maps and charts which were made from the data so that one can tell at a glance the present situation of the traffic in Chicago. For example, one map showed where all the people working in the loop resided, only four per cent being within walking distance. Another showed where people working in the various manufacturing districts lived, approximately sixty per cent (60%) living within walking distance according to the data obtained. Other maps show the number of people entering and leaving the "L" system in certain districts giving the proportion who enter at one station and leave at another. The manner in which the commission has represented the conditions graphically is really remarkable.

From the results obtained, the commission could see at a glance where the traffic system needed to be remedied. The congestion on the surface lines, they believe, can be relieved by a complete rerouting of the cars and the installation of more track so as to change the way in which the people travel between home and work at present. It would take too much space here to go into elaborate rapid transit system worked out by the commission nor would the treatment here do them justice. A point or two in regard to the new "L" system may however not be out of order.

The North and South Side "L" system is to be a four track system. A subway is planned along State Street between Eighteenth Street and Chicago Avenue. At Chicago Avenue the

trains will turn west and connect to the old North Side system. The trains will run both north and south on this route. In addition there will be a north and south system along Fifth Avenue, the trains running to Polk Street and turning east on Polk Street to the old South Side system. Thus there will be a north and south side system both along Fifth Avenue and along State Street. With the present system loop workers from the north side get off usually at stations along Fifth Avenue and walk east into the loop while those from the south side get off along Wabash Avenue and walk west, causing much congestion in the loop during rush hours. With the new system, loop workers living north or south would be able to take trains either at State Street or Fifth Avenue which will mean a travel outward and inward from the center of the loop and thus a relief of much of the congestion.

The Chicago and Oak Park Elevated system and the Metropolitan Elevated system are planned to go around the loop, passing over the Fifth Avenue structure of the north and south side "L" system. Transfer points are proposed at Fifth Avenue and Lake Street and at Fifth Avenue and Van Buren Street. Thus one wishing to travel from the west side to the north side may transfer directly at these transfer stations doing away with present necessity of travelling around the loop.

Mr. Brinkerhoff pointed out numerous other features of the proposed rapid transit system. On the whole, one cannot help but say that the commission has completed what was considered an almost hopeless task, and has presented the feasible step forward in the relief of the present traffic congestion in Chicago.

We take our hats off to the commission, and hope that some of the Armour men may have the good fortune of aiding them in having the plan passed upon, and also in the building up of the proposed rapid transit system after it has been sanctioned by the city.

American Association of Engineers.

On January 15, 1917, at 4 p. m., Mr. A. H. Krom and Mr. T. H. Williams of the American Association of Engineers addressed the student body in the Physics Lecture Room. Mr. Krom gave a talk on the objects and benefits of the Association. The organization is made up of all of the classes of engineers and

its main object is to raise the standard of ethics of the engineer. With capital on one side and organized labor on the other, it seems that the engineer is the go-between and has not much of a chance unless he sticks with his fellow engineers. The Association is one means of securing this fellowship. It also maintains a service clearing house or employment agency for the benefit of its members.

After the talk by Mr. Krom, a general discussion took place and various questions were raised. A motion was made and passed that a temporary membership committee be appointed to look into the A. A. E. and advice what should be done at Armour. The committee consists of Mr. H. D. Stevers, chairman, Mr. H. W. Puschel, Mr. R. A. Newlander, Mr. H. Luttge and Mr. L. H. Rosenberg.

The Association offers great opportunities to the student members, greatest of which are: first, encouragement in business training; second, the starting of a record for character and training in the files of the National Headquarters; third, sales services and co-operation when employment is needed. The requirement at present are no initiation fee, dues $3.00 per year (one dollar for the Monad, the monthly publication of the Association, and the balance for local chapter expenses) for Junior and Senior students in Engineering Schools of recognized standing. The present enrollment is 1,590.

The American Association of Engineers at Chicago has received an application for a charter for a local chapter at the University of Illinois. It was signed by twenty certified and student members at the University. This will be the first Engineering University Chapter of the "Engineers National Busines Organization." Keen competition has existed among several of the large engineering schools for this honor and Illinois winning only by a small margin as several other schools are very active. The temporary officers are D. R. Norris, Chairman, Victor A. Pecchia, Secretary, and Harry E. Fisher, Treasurer. Professors F. H. Newell, head of Department of Civil Engineering, Ira O. Baker and J. A. DeHurk of the University, are actively assisting as members of the new chapter. This chapter was formed thru the efforts of one man, D. R. Norris, a Junior student last year, who became a student member while enployed

by the I. C. R. R. for the summer vacation. While in Chicago he imbibed the A. A. E. spirit so strongly that he undertook the formation of the first Student Chapter immediately upon his return to the University.

Why not have a chapter at Armour? If we can't be first let us at least be among the first.

On Wednesday morning, February 28, Major Paul B. Malone, of the United States Army, officer in charge of the Central Department training camps, addressed the college in assembly, on thet subject of civilian training. He told of the work that the government has done and is planning to do in preparing civilians for military service when the time will come for such service. His lecture was illustrated by lantern slides of the work done at the Training Camp held at Plattsburg in 1916.

Major Malone explained the training camp system, and also the new Officers' Reserve Corps, authorized by Act of Congress. His subject is of especial interest at the present time, and it is to be hoped that his visit to Armour will be instrumental in awakening the college to the miltary needs of the country and the part that it should play in satisfying those needs.

All students and members of the faculty who fulfill the moral and physical requirements set forth by the orders authorizing the camps, are eligible to attend. Under the Army Reorganization Bill of 1916 the government pays the expenses of attendants, and supplies full field equipment. The camps are held at various centrally located posts throughout the country for four-week periods during the summer months. Information may be secured by addressing the Military Training Camps Association, Federal Building, Chicago.

Engineering Societies

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

President .... G. M. Fritze
Vice-President .... R. G. Pomeroy
Secretary .... E. W. Haines
Treasurer .... Harold S. White

The meetings that have been held lately have been very interesting, the speakers presenting their subjects in a very pleasing manner. The subject "The Removal of Impurities from Boiler Feed Water," was given by Mr. Steindler at our meeting of January 31st. A short talk was also given by Mr. Robechek on the "Heat and Emulsion Tests of Oils." Mr. Kerr explained the different types of water air compressors as used on the different rivers of the United States and Canada. An impromptu talk was given by Mr. Bretting on the use of the by-products of the forest. He compared the modern methods of utilizing all of the tree with the older method of fifteen years ago of wasting fifty per cent of the wood.

At the next meeting it was decided to hold a smoker on March 7th in the Y. M. C. A. rooms to which the Freshmen and Sophomore mechanicals were to be invited.

A talk was given by Professor Gebhardt on "Advice to the Engineer" which was very much appreciated.

A talk was promised by Mr. Swineford on "Safety Engineering" at the next meeting. The meeting closed at 8:05 and everybody went their way feeling that they had spent a very satisfactory evening.

E. W. Haines.

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE O FELECTRICAL ENGINEERS

Chairman ....R. H. Earle
Secretary ....H. A. Kleinman
Treasurer ....W. T. Watts

The meeting of February 6, 1917, devoted to a demonstration of radio phenomena, was conducted by Messrs. Stevers and Mathews. A complete receiving station was installed in Science Hall, and signals were received from various government and private stations of the country. The weather report from Arlington, Va., was heard about nine o'clock, and messages from ships on the Atlantic Ocean were picked up at various times during the evening.

The feature of the evening, however, was the receipt of music sent by Mr. Howard of Maywood by prearrangement. Various phonograph records were heard with remarkable clarity considering the atmospheric conditions at the time.

Mr. Stevers gave a lecture on the development of the wireless apparatus, and illustrated his talk with slides showing various pieces of apparatus and some noted stations. Mr. Mathews had charge of the apparatus and conducted the experimental part of the demonstration. The messages were audible to everyone in the room by means of a microphone and loud-speaking receiver.

We wish to thank these two men for this interesting and educational demonstration. We also extend our hearty thanks to Mr. Howard who loaned apparatus and spent his time in sending music through twenty miles of space for our entertainment.

H. A. Kleinman.

THE CIVIL ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY.

President ....A. L. Schreiber
Vice-President ....L. E. Starkel
Recording Secretary ....S. N. Miller
Corresponding Secretary ....H. W. Stride
Treasurer ....C. L. Shaw

Although a meeting had been scheduled for January 2nd, 1917,

it was found impossible to secure a speaker so soon after the Christmas vacation, and no meeting was held.

January 16, 1917. An illustrated talk on "The Panama Canal," by Professor Penn. This was a survey of the design. construction, and operation of the great canal, together with a brief outline of the administration and sanitation of the canal zone.

February 5, 1917. A talk by Mr. C. C. Sauer, Assistant Engineer in the Department of Hydraulic Design of the City Waterworks of Chicago. Mr. Sauer explained by charts and diagrams the methods used in locating pumping stations, areas served, and size of tunnels required for this service.

February 28, 1917. The Lake Spaulding Development. This was an illustrated talk for both the A. C. E. S. and the A. I. E. E. The slides were furnished by the Pelton Waterwheel Company, and the description of construction was given by Professor Dean of the Civil Department, with the operation of the completed plants was explained by Professor Freeman of the Electrical Department.

H. W. Stride.

THE CHEMICAL SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY.

President .... A. H. Smith
Vice-President .... D. E. Cable
Secretary .... A. G. Fitzner
Treasurer .... O. L. Hailey

The society met at 8:00 p. m. Tuesday evening, February 27th, and enjoyed a practical lecture from Mr. Brewster of the Wisconsin Steel Company. The subject matter was confined to the main features involved in the production of iron from its ore. The following outline gives the points discussed:

1. Transportation of the ore; unloading and transferring to the stock pile; classification of unloaders and the main points of difference.

2. The charge. The calculation of and means of delivery to the furnace hopper.

3. Furnace hopper; advantages and disadvantages with regard to maintainence, cost, distribution of charge, etc.

4. The results of improper distribution of the charge in the furnace.

5. The blast.

a. Machines used to produce the blast and a comparison of them.

b. The effect of variations in the blast.

6. Preheating. Classification and main features of the two pass, three pass and four pass stoves.

7. Gas washers and dryers and their present limitations.

The lecture gave us a little more regard for the word Experience as we were brought face to face with the fact that the most successful operation of the various processes is only possible with strict adherence to details which have been found to work out to the best advantage.

A. G. Fitzner.

THE FIRE PROTECTION ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY.

President ....A. Corman
Vice-President ....H. B. Maquire
Secretary ....H. W. Puschel
Treasurer ....L. W. Mattern

The society was honored with a lecture by Mr. F. Taylor (class of '07) Protection Engineer, Underwriters' Laboratories, on Thursday evening, January 8, at 8 p. m. The meeting was held in the Engineering Rooms of Chapin Hall. Until last year Mr. Taylor was head of the Fire Protection Engineering Dep't. at Armour. Therefore the event was more or less in the nature of a home-coming.

Mr. Taylor's topic was the "Development of the Underwriters Laboratories." It was very fitting that he should speak on this subject because he has been with the Underwriters' Laboratories from practically the start, and is at present one of the leading men at the Laboratories. In a most informal and pleasant manner, he traced the development of the Laboratories from the time it began, some fifteen years back, up to the present date.

It is almost unbelievable that the Underwriters Laboratories could have developed from the efforts of three or four men in fifteen short years—but so it did. It illustrates the need that

existed for some means of systematic investigation of fire protection apparatus.

During the time of development, the men came in contact with experiences of every sort. Many were funny and some very serious, but all were instructive.

Mr. Taylor devoted the evening to a summary of those more important events that helped to shape the institution to what it is today. The meeting was probably the most pleasant we have ever had.

Through he auspices of Mr. Owen, the society had the pleasure of having Mr. Gartside, Examiner, National Fire Insurance Co., deliver a lecture on "Underwriting Methods." Mr. Gartside first gave a brief history of fire insurance, then gave a brief description of the "inner workings" of an ordinary insurance company.

A few of the more important points he brought out may be mentioned. The first insurance company as we know it today, was established in 1606, and the oldest company existing today was established in 1706. The Chicago and Boston fires caused many companies to fail. Mr. Gartside said that figures show the annual fire loss to average about $250,000,000.00. This is all together too large a loss, and should be reduced.

Next he told how an insurance policy is made out from the time the agent gets a "line" on it, to the time when the insured receives the policy. On big risks, amounting to sometimes a million dollars, and often high in the hundreds of thousands of dollars, this requires a great deal of offiice work and investigation. For such large risks, and all other so-called improved risks, we have the special agent.

In closing, Mr. Gartside gave some real practical advice to the men who will soon be out in the field as inspectors or special agents. He drew from his own experience, and also that of other men.

The talk was very valuable indeed, and gave all those present a deeper insight into their profession. We heartily thank Mr. Gartside for his talk, and hope that in the future he may find time to visit us again.

THE ATELIER.

Massier ....H. Ingraham
Secretary ....J. W. Turner
Treasurer ....K. A. McGrew

The activities of the Atelier during the past few months have been greater than ever before in its history. By special arrangement, Mr. Daniel S. Garron gave three very interesting and instructive lectures on "Architectural Indictaion." They were very well attended, not only by our own members, but also by the Atelier Rebori and the Chicago Architectural Club. The enthusiasm shown by all resulted in making the lectures a financial as well as an educational success.

An impromptu banquet was given about the same time, and the latent energy of the Arch's was displayed in full. Everyone took part, and it was surprising how decorations, eac., were suddenly brought to light to help the affair along. Special thanks are due to Mr. Monaco and Mr. Grammas, who were chief providers and cooks. Not a thing was lacking to grace our makeshift banquet board, and, as Toastmaster Chappell afterwards remarked, "A great time was had by all." We hope to repeat the event in the near future.

The annual Mardi Gras of the Art Student's League gave another opportunity for the display of "pep," and the Atelier joined in with a will. Their booth, "Ye Old Tickle Your Palate Inn," was the principal attraction of the evening, being a representation of an Old English Tavern. Soft drinks and ice cream were sold, and, owing to the forethought Mr. Dryden, the supply was equal to the demand and a handsome profit was the result. A pageant portraying the reception of the Classic Renaissance by the English Gothic architects was given by the Architects and was pronounced by everyone to be the most beautiful and extensive thing of its kind ever shown at a Mardi Gras. Great credit and thanks are due to Professors Reed and Campbell for the help and interest they displayed during the whole production.

K. A. McGrew.

Armour Institute of Technology Library

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THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.

Edited by the Publication Committee of the Armour Alumni Association.

F. G. Heuchling F. T. Bangs W. H. Lautz

Communications should be addressed to F. T. Bangs, 608 South Dearborn Street, Chicago, Ill.

IN RE FINANCES.

In these days of publicity no apology is necessary for calling attention to the finances of the Association. This requires first a brief review of its activities.

The primary objects of the Association are to promote good fellowship among the alumni and enable them to keep in touch with each other and with their alma mater. To do this it holds semi-annual reunions in Chicago, to which every alumnus is invited, and it makes earnest efforts to reach every alumnus by correspondence from two to five times each year. To those who support the Association, it sends the Armour Engineer as the best available medium for disseminating news of the alumni and of the Institute.

The financial affairs of the Association are conducted in the most economical manner. The officers receive no salaries or gratuities. Expenditures for dinners and entertainments at

the reunions are met by those in attendance, so that the general funds are used only for mailing, printing, records, and members' subscriptions to the Armour Engineer.

To finance its needs the Association depends entirely on its members, who pay annual dues of \$1. These dues with initiation and reinstatement fees and interest on the loan fund, to be referred to below, constitute the entire income. With these resources the Association has maintained itself in excellent financial condition.

Although the Association is under no actual obligation to render any service to those who fail to support it, it has felt it to be highly desirable to keep in touch with every alumnus of the Institute to the extent at least of recording his occupation, address, etc. This has entailed additional mailing and incidental expenses, however, which has been met by those (less than half the total alumni) who now support the Association. The situation calls for increased efforts to make every alumnus become and remain an active member, so that the Association's burdens can be met equitably by all.

Heretofore it has devolved almost entirely on the treasurer to increase the membership by collecting the small fee and dues that convert an alumnus into an active member. This is a large task for one individual, whose ordinary duties already take up much time. Moreover, the treasurer's statements and form letters are seldom as effective as a few words from a former classmate or friend. Every member (and particularly the respective class "boosters") should therefore actively aid in this work by getting alumni to join. All that is necessary is to get the men to send to the treasurer \$1 for initiation and \$1 for dues. Assistance would also be appreciated in getting men known to be delinquent to send \$1 for reinstatement and \$1 for dues.

There is no reason why the Association should not have an active membership of at least 80 per cent of all the alumni. Every alumnus should be able to contribute the modest annual dues, which are less than those of similar alumni organizations. Could we raise the membership to this percentage, a substantial increase in the revenue of the Association would result, together with a decrease in its overhead expense.

Some possibilities of increased service, if the funds were

available, are as follows: More complete, accurate, and readily available alumni data; establishment of an alumni employment service in co-operation with the Institute; publication of a special alumni bulletin; creation (out of surplus funds and donations) of one or more alumni scholarships.

Several years ago the Association made it possible for a member in good standing to become a life member by paying $20, which is put into a separate fund that is loaned to students in need. The interest on this amount goes into the general fund and is practically equivalent to the member's annual dues. There are now 68 life members who have contributed to this fund and one generous member has made several supplementary donations.

The above is an instance of the good which the Association has been able to accomplish with its present income. With materially increased resources it should certainly be able to increase its usefulness decidedly. The Association is nearly 20 years old, during which it has evolved into an organization of value not only to the alumni but also to the students and the Institute. Surely it is time that it received the active support of *all* the alumni in order that it may greatly broaden its utility and influence.

F. H. Bernhard

ALUMNI NOTES.

Harry B. Aarens, '16, is draftsman with Arthur Woltersdorf, architect, 138 North La Salle Street, Chicago.

John F. Adamson, '15, is in the engineering department, Chicago Fuse Manufacturing Company, 1014 West Congress Street, Chicago.

Claude R. Alling, '07, has been promoted from assistant to division engineer, Underwriters' Laboratories, 207 East Ohio Street, Chicago.

Harold E. Anning, '16, is chemist with the L. E. Myers Company, Monadnock Block, Chicago.

John W. Baring, '16, is working for the Commonwealth Edison Company, Chicago.

H. E. Brashears, '05, formerly assistant signal engineer, Great Northern Railway, is now signal engineer, Chicago Railway Signal and Supply Company, Carpentersville, Ill.

C. L. Bolte, '16, is chemist on the laboratory staff, railway engineering department, University of Illinois.

W. T. Braun, 13, who was instructor in the Coyne Trade School, now has architects' offices at 189 West Madison Street, Chicago.

H. A. Merriman, '11, is a member of the firm of Merriman & Neighbours, architectural engineers, 1116 Story Building, Los Angeles, Cal.

J. C. Michael, '12, is now distribution engineer, Commonwealth Edison Company. We are informed that he went to Brownsville with the Illinois National Guard last summer.

It is with a feeling of extreme regret that we record the death of Elmer E. Erickson, '14, which occurred in Chicago, February 8, due to accidental asphyxiation. He was born in Cleveland in 1892 and received his preparatory education at Lake High School, Chicago. At college he became known for his courteous and unassuming manner, his industriousness and his practical turn of mind, qualities which made for him friends of everyone who came to know him. He was graduated with honors from the course in mechanical engineering and was a member of Tau Beta Pi. After graduation he entered the engineering department of Armour & Company, Chicago, later accepting a position with Swift & Company. His personality and education gave promise of an exceptionally successful career, and his untimely death is mourned by his many sincere friends.

Fred A. Niestadt, '09, formerly superintendent of construction, with J. H. Sutter, contractor, Chicago, is now structural engineer, Wilder Tanning Company, Waukegan, Ill.

A. C. Noble, '01, has become vice-president, Merchants Fire Assurance Corporation, 1 Liberty Street, New York City.

Irwin Newman, 13, is representing the Reeves-Cubberly Engine Company of Trenton, N. J., with offices at 725 Monadnock Block. Chicago.

Benjamin Natkin, '05, is now president of the Natkin Engineering Company, 304 Finance Building, Kansas City, Mo.

J. C. Norton, '15, is at Hurley, N. M., where he is associated with the Chino Copper Company.

Jess Agee, '15, formerly with the Consumers Company, Chicago, is now with Sanderson & Porter, engineers, 72 West Adams Street, Chicago.

Carl Haase, '16, is service investigator, Commonwealth Edison Company, Chicago.

Arthur Heeren, '16, is draftsman, Chicago, Milwaukee & St. Paul Railway, 719 Lyon & Healy Building, Chicago.

H. W. Hemple, '16, is in the architectural department, Armour & Company, Chicago.

Nathan Isenberg, '16, is chemical engineer in the coke plant of the Midland Steel Company, Indiana Harbor, Ind.

F. M. Isensee, '14, is draftsman with Swift & Company, Union Stockyards, Chicago.

P. O. E. Johnson, '13, is now sales engineer, W. H. Treadwell & Company, 208 South La Salle Street, Chicago.

V. E. Marx, '16, is chemical engineer, Sawyer Biscuit Company, 1029 West Harrison Street, Chicago.

H. N. Parsons, '11, who was working in the engineering department, City of Chicago, recently accepted a position as sales manager, Johnson Engineering Works, 1734 First National Bank Building, Chicago.

W. G. Stansel, '13, formerly in the signal department of the Chicago, Burlington & Quincy Railroad, recently accepted the position of assistant signal engineer, Chicago, Joliet & Eastern Railroad, Joliet, Ill.

Edward L. Nelson, '14, formerly in the electrical department, Pullman Company, Chicago, has joined the staff of engineers in the Western Electric Company's research laboratories in New York City.

John R. Charlton, '14, has been transferred from the Chicago office of the American Telephone & Telegraph Company to its offices in Maumee, Ohio (near Toledo), the transfer involving a promotion for J. R.

Carlyle Peek, '16, is draftsman with Hall & Ostergren, architects, 11 South La Salle Street, Chicago.

G. B. Perlstein, '16, is chemist in the research laboratory, Armour & Company Fertilizer Works.

William Paterson, '15, is mechanical engineer, motive power department, Armour & Company, Chicago.

Earl Porter, '16, is city editor of the *Atlantic News;* Atlantic, Iowa.

C. S. Packer, '08, is salesman, Lackner & Butz, investment bankers, 111 West Washington Street, Chicago.

W. I. Parker, '05, has been appointed sales manager of the Packard Electric Company, Warren, Ohio.

W. S. Pfeifer, '15, who was testing engineer, Economy Fuse & Manufacturing Company, Chicago, has become assistant in the traffic engineering department, Wisconsin Telephone Company, Milwaukee.

H. M. Shapiro, '16, is service investigator, Commonwealth-Edison Company, Chciago.

G. N. Siebenaler, '16, is draftsman with Torris Wold & Company, 240 North Ashland Avenue, Chicago.

Ernest Sieck, '15, formerly with the American Coal & By-Products Coke Company, Chicago, is chemist with the Dover By-Products Company, Dover, Ohio.

C. R. Simmons, '15, is efficiency engineer, Thomas Moulding Brick Company, 1203 Chamber of Commerce, Chicago.

W. W. Sir, '15, is in the motive power department, Armour & Company, Chicago.

B. M. Smith, '16, is with W. L. Fergus & Company, consulting mechanical and electrical engineers, 1509 Fisher Building, Chicago.

O. A. Skinner, '16, is with Reed & Haagen, architects, 139 North Clark Street, Chicago.

S. E. Sosna, '16, is employed by the Concrete Steel Company, 1105 Monadnock Block, Chicago.

B. B. Sostheim, '16, is sub-instrument man, Sanitary District of Chicago.

C. H. Spencer, '13, formerly with the Link Belt Company, is now mechanical engineer, Fairbanks, Morse & Company, Chicago.

A. H. Spitz, '16, is senior architectural draftsman, engineering department, South Park Commissioners, Chicago.

G. I. Stadeker, '09, formerly sales engineer, Western Electric Company, has established the Stadeker Metal Specialty Company, with offices at 19 South Fifth Avenue, Chicago.

H. C. Stanley, '13, is architect with the King Ventilating Company, Owatonna, Minn.

C. G. Stecher, '14, is employed by the Western Union Telegraph Company, but at the present time is with the Illinois Signal Corps at Fort Sam Houston, Tex.

A. C. Steigley, '10, is architectural draftsman, Central Manufacturing District, S. Scott Joy, architect, 1113 West Thirty-fifth Street, Chicago.

J. L. Stewart, '13, is now sales engineer, Clinton Wire Cloth Company, 111 West Washington Street, Chicago.

R. H. Salisbury, '10, is now chief draftsman, department of buildings, Chicago, Burlington & Quincy Railway, 547 West Jackson Boulevard, Chicago.

P. A. Strong, '12, is employed by Sears, Roebuck & Company, Chicago.

J. B. Burnett, '01, formerly mechanical engineer, Palmer-Dee Company, Detroit, is sales engineer, American Steam Conveyer Corporation, Hearst Buidling, Chicago.

H. W. Vader, '16, is with Shattuck & Hussey, architects, Y. M. C. A. Building, Chicago.

N. Vanderkieft, '13, who has been with the Pullman Car Company, is now engineer, Midland Steel Company, Indiana Harbor, Ind.

W. H. Volz, '16, is with Miller, Fullenwider & Dowling, architects, 6 North Michigan Avenue, Chicago.

Theodore Wachs, '07, formerly superintendent, Banroth Machine & Tool Company, Toledo, Ohio, is engineer for the E. H. Wachs Company, 1525 Dayton Street, Chicago.

R. A. Walther, '09, is now in the valuation department, Chicago & North Western Railway, Chicago.

E. R. Weber, '03, has been promoted from division engineer to chief of the production department, Bucyrus Company, South Milwaukee, Wis.

C. L. Wetzel, '14, is instructor in shop electricity, Lathrop School of Mechanical Trades, Kansas City, Mo.

G. F. Wetzel, '15, formerly with the International Filter Company, is now in the engineering department, Western Electric Company, Hawthorne Works.

A. C. Wermuth, '16, is assistant superintendent, Wells Brothers Company, Ft. Wayne, Ind.

H. B. Wilkens, '16, is chemist and factory foreman, Essenkay Products Company, 539 Orleans Street, Chicago.

Chester F. Wright, '16, is in the traffic engineering department, Western Union Telegraph Company, Chicago.

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FLOW OF FLUIDS AND FRICTIONAL RESISTANCE IN PIPES

BY J. M. SPITZGLASS*

PART II—INTERNAL FRICTION

The fundamental equation $f\frac{V^2}{2g} = \frac{H}{L} \times \frac{D}{4}$ (equation 2, part 1), is based upon the assumption that the opposition to the flow is caused by "skin friction" only. This would be true if the molecular attraction, or the viscosity of the fluid were large enough to keep the particles together, as in the case of a rigid body. In that case the effect of the frictional resistance would be transmitted by the molecular attraction from the surface to the inner layers and it would be equally distributed over the entire cross section of the flow in the pipe. Only with that assumption would the relation demonstrated in the first part of this work hold true, and the co-efficient of friction "f" would be the same theoretically, for a given kind of rubbing surface.

On the other hand if we should consider the flow of an extremely mobile and frictionless fluid, where the molecular attraction is negligible, we would expect the outermost layer of the fluid to be retarded by the contact with the solid walls of the pipe. This would have no effect upon the inner layers which are not touching the walls, and these layers, or practically, the whole cross-section of the flow, would continue to move at the uniform velocity without any loss of energy or drop of pressure in the line, because the contact of the flowing mass with the mobile and frictionless layer retarded by the rough surface of the walls would offer no resistance to the flow.

We are well familiar with the viscosity of lubricating oils or the property of adhesion which tends to hold the particles of a given mass in continuous contact with those of another mass, or with each other. This property of adhesion is com-

*Class 1909. Inventor of the Spitzglass Slide Rule and Flow Computer.

paratively very small in the case of gases, as in the case of the so-called non-viscous fluids. It is however, by no means negligible even in those fluids, otherwise such gases and liquids flowing in a given pipe would have the same velocity over the whole cross-section of the flow, and there would be no drop of pressure or loss of energy in the line.

From experiments in traversing pipes with Pitot tubes, indicating the velocity pressure at the various points of the cross-section, we find that the longitudinal section of the flow, in plotting velocities to scale, takes the form of a parabola with the focus close to the center of the pipe, where the maximum velocity of the fluid is obtained. It appears, therefore, that when the outermost film of the flow is opposed by the tangential resistance at the walls of the pipe, there is a tendency to transmit this opposition to the inner layers which are bound to each other to a certain extent by the elastic force of adhesion.

This tendency, however, is limited to the magnitude of the adhesive force which is not large enough to keep the layers completely together when the surface is resisted tangentally by the skin friction of the pipe. For this reason the flow is retarded in a larger measure nearer to the perimeter of the pipe and the inner layers of the fluid break away from each other following with increased velocities from the surface towards the center of the pipe, until the total effect of skin friction is counter-balanced by the force of adhesion, resisting the relative motion between the layers of the fluid.

The effect of the uneven velocities of the fluid in the pipe is to set up an internal resistance to the flow by the adjacent particles of the fluid, being separated from each other continuously against the force of adhesion. It may be stated in this regard, that the *skin friction* is virtually carried by the *tendency of the particles of the fluid to keep together,* while the *internal friction* is caused by the *failure of this tendency to keep them completely together.*

Applying these principles to the fundamental relations expressed in equation 1, Part 1, bearing in mind that the skin friction varies with the rubbing surface, while the internal friction is a function of the relative motion and of the cross-section of the pipe, we can write:

$$f_1 \frac{V^2}{2g} w\pi D + f_2 \frac{V^2}{2g} w + f_3 \frac{V^2}{2g} w \frac{\pi D^2}{4} = \frac{Hw}{L} \times \frac{\pi}{4} D^2 \quad \ldots.(24)$$

Removing equals and transposing,

$$\left(f_1 + f_2 \frac{1}{\pi D} + f_3 \frac{D}{4}\right) \frac{V^2}{2g} = \frac{H}{L} \times \frac{D}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots(25)$$

Substitute a for f_1, ab for $\frac{1}{\pi} f_2$ ac for $\frac{1}{4} f_3$ and let f, represent the composite value of the co-efficient of friction; we have

$$f = a + \frac{ab}{D} + acD = a\left(1 + \frac{b}{D} + cD\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots(26)$$

Where a, b and c, are constants depending upon the roughness of the surface and the viscocity of the fluid, and D, the diameter of the pipe.

With this value of f, all the equations derived in Part 1, are applicable to the flow of fluids, taking into consideration the elasticity of the fluid and the effect of internal friction in the pipe.

PART III—PRACTICAL APPLICATIONS

The equations for the flow of fluids in pipes, as derived in part one, are used in various modified forms for determining sizes of pipes, or quantity of flow for practical installations of pipe lines. It is generally admitted, as implied by these quations, that the drop of pressure due to friction, other things being equal, should be:

1. Directly proportional to the kinetic energy of the flowing mass.
2. Directly proportional to the amount of rubbing surface per unit cross-section of flow.
3. Directly proportional to the roughness of the surface in contact.

The roughness of the surface is represented by the experimental co-efficient f, which is known to be nearly the same for all non-viscous fluids, as water, steam and the ordinary gases. It is also considered that for the same kind of surface the coefficient varies with the velocity of the fluid and with the diameter of the pipe.

Experimenting on the flow of water in the Paris water mains in 1897, Darcy proposed an expression for the co-efficient of friction to take the form of

$$f = a\left(1 + \frac{b}{D}\right) \qquad (27)$$

where a and b, are quantities depending upon the roughness of the rubbing surface, D, representing the diameter of the pipe.

Eitelwein, later proposed the expression:

$$f = a\left(1 + \frac{b}{V}\right)$$

V, representing the velocity of the fluid in the pipe.

Weisbach, proposed the form:

$$f = a\left(1 + \frac{b}{[V]^{1/2}}\right)$$

Fanning computed extensive tables giving numerical values fro "f", varying with diameter of pipe and velocity of the fluid, the values ranging from $f = .0150$ for ½ inch pipe and 0.1 feet per second velocity, to $f = .00313$ for a 60 inch pipe and 12 feet per second velocity.

In the flow of gases the constant value of $f = 0.006$ was used for all conditions, until 1904 when Unvin introduced Darcy's form with numerical values of

$$f = 0.0027\left(1 + \frac{3.6}{D}\right)$$

D, being the diameter of the pipe in inches. This expression was also incorporated into many formulas proposed for the flow of steam in pipes.

The writer had the privilege of participating in a long series of experimental tests conducted by the laboratory force of the Peoples Gas Light & Coke Company of Chicago, under Mr. R. B. Harper, on the flow of gas in street mains and service pipes. These experiments are given in large detail in the proceedings of the Illinois Gas Association, 1912 (pages 118-149).

From the detailed figures of the tests it was shown that, for the same size of pipe, the square root of the friction drop includes a constant amount after the substraction of which the

remainder varies in direct proportion with the quantity of gas discharged through the pipe. At small velocities of the gas and short lengths of pipe, this constant forms a large percentage of the total, making the discharge apparently vary as the drop and not as the square root of the drop of pressure. At larger velocities, however, the initial drop becomes insignificant and the theoretical proportion holds fairly true for any given size of pipe.

The further analysis of the results disclosed that the variation of the co-efficient of friction with the size of the pipe is very noticeable in all cases. The tests have shown that the co-efficient of friction has a minimum value between the 10 inch and the 12 inch pipes. For smaller pipes the co-efficient increases rapidly; for larger pipes the co-efficient also increases, but not so rapidly. This indicated that the expression $f = a\left(1 + \frac{b}{D} + cD\right)$ as derived in part II, equation 26, will hold true for all sizes, because it takes care of the variation in both directions.

From the data of the tests the average value of the co-efficient was shown to be

$$f = .00285\left(1 + \frac{3.6}{D} + .03\,D\right) \dots\dots\dots\dots (28)$$

To determine the exact diameter of the pipe at which f is a minimum, we differentiate equation 28, with respect to D, and equate the result to zero; we have

$$-\frac{3.6}{D^2} + .03 = 0;$$

$$D^2 = \frac{3.6}{.03} = 120; \quad D = (120)^{1/2} = 11 \text{ inches approximately.}$$

SUMMARY OF FLOW EQUATIONS

The equations for the flow of fluids in pipes as derived in Parts I, and II, are conveniently summarized in the following formulas for practical application. In these formulas the absolute system of units was replaced by those ordinarily used for the given cases.

Flow of Gases—High Pressure

From equation 23, we obtain for the given units:

$$Q = 3.55\left(\frac{1}{f}\right)^{1/2}\left(\frac{PAD^5}{SL}\right)^{1/2} \quad \ldots\ldots\ldots\ldots (29)$$

Using the value of *f*, from equation (28), we have

$$Q = 66.5\left[\frac{PAD^5}{SL\left[1+\frac{3.6}{D}+.03D\right]}\right]^{1/2} \quad \ldots\ldots\ldots (29a)$$

$$\text{or,}\quad Q = 66.5\left[\frac{D^5}{1+\frac{3.6}{D}+.03D}\right]^{1/2}\left(\frac{PA}{SL}\right)^{1/2} \quad \ldots\ldots (29b)$$

In equations (29), (29a) and 29*b*),

Q, designates cubic feet of gas per hour reduced to standard conditions of 30 inches pressure and 60 deg. F. temperature.

P, friction drop of pressure, pounds gauge;

A, Mean pressure in pipe line, pounds absolute;

D, Diameter of pipe, inches;

L, Length of pipe, miles;

S, Specific gravity of gas referred to air;

f, Experimental co-efficient

$$= .00285\left(1+\frac{3.6}{D}+.03\,D\right)$$

Flow of Gases—Low Pressure

When the pressure of the gas in the line is close to the standard atmospheric pressure of 30 inches of mercury or 14.7 pounds per square inch, the drop is usually measured in inches of water, and from equation (23) by changing the units, we obtain

$$Q = 18.95\left(\frac{1}{f}\right)^{1/2}\left(\frac{hD^5}{SL}\right)^{1/2} \quad \ldots\ldots\ldots (30)$$

and substituting the value of f,

$$Q = 3550 \left[\frac{hD^5}{SL\left[1 + \frac{3.6}{D} + .03D\right]} \right]^{1/2} \quad \ldots\ldots\ldots (30a)$$

$$\text{or, } Q = 3550 \left[\frac{D^5}{1 + \frac{3.6}{D} + .03D} \right]^{1/2} \left(\frac{h}{SL} \right)^{1/2} \quad \ldots\ldots\ldots (30b)$$

In equations (30), (30a) and (30b), the notation is the same as in (29), (29a) and (29b) for Q, D and S. Of the others:

h, designates friction drop of pressure, inches of water;
L, length of pipe, feet.
f, experimental co-efficient

$$= .00285 \left(1 + \frac{3.6}{D} + .03D \right)$$

Flow of Water

From equation 8, we obtain

$$Q = 2.85 \left(\frac{1}{f} \right)^{1/2} \left(\frac{HD^5}{L} \right)^{1/2} \quad \ldots\ldots\ldots (31)$$

Replacing f; we have

$$Q = 53.4 \left[\frac{HD^5}{L\left[1 + \frac{3.6}{D} + .03D\right]} \right]^{1/2} \quad \ldots (31a)$$

$$\text{or, } Q = 53.4 \left[\frac{D^5}{1 + \frac{3.6}{D} + .03D} \right]^{1/2} \left(\frac{H}{L} \right)^{1/2} \quad \ldots\ldots\ldots\ldots (31b)$$

In equations (31), (31a) and (31b)

Q, designates gallons of water per minute;
H, friction drop of head, feet;

D, diameter of pipe, inches;
L, length of pipe, feet;
f, experimental co-efficient

$$= .00285 \left(1 + \frac{3.6}{D} + .03D \right)$$

Flow of Steam

It is assumed that the friction drop of pressure in the line causes a uniform reduction in the density of the steam. The error introduced by this assumption is entirely negligible as it involves only the difference between the density of the steam at the mean pressure, and the actual mean density of the flow; this difference is very small in all ordinary cases. With this assumption the modified form of equation 20, will yield;

$$W = 4.55 \left(\frac{1}{f} \right)^{\frac{1}{2}} \left(\frac{PD^5 w}{L} \right)^{\frac{1}{2}} \quad \ldots\ldots (32)$$

Replacing *f*, we have

$$W = 85.2 \left[\frac{PD^5 w}{L \left[1 + \frac{3.6}{D} + .03D \right]} \right]^{\frac{1}{2}} \quad \ldots (32a)$$

$$\text{or, } W = 85.2 \left[\frac{D^5}{1 + \frac{3.6}{D} + .03D} \right]^{\frac{1}{2}} \left(\frac{Pw}{L} \right)^{\frac{1}{2}} \quad \ldots\ldots\ldots (32b)$$

In equations (32), (32a) and (32b)

W, designates pounds of steam per minute;
P, friction drop of pressure pounds gauge;
L, length of pipe, feet;
w, density of steam at mean pressure, pounds per cubic foot;

f, experimental co-efficient $= 00285 \left(1 + \frac{3.6}{D} + .03D \right)$

The writer has developed a slide rule giving the direct solution of the Flow Equations enumerated above. The following tables will be of assistance to those who wish to solve the equations without the use of the special Slide Rule.

Denote by "K" the radical, $$\left[\frac{D^5}{1+\frac{3.6}{D}+.03D}\right]^{1/2};$$

then the equations for the flow of the given fluids can be written:

Flow of High Pressure Gas: $$Q = 66.5\,K\left(\frac{PA}{SL}\right)^{1/2} \quad \ldots (29c)$$

Flow of Low Pressure Gas: $$Q = 3550K\left(\frac{h}{SL}\right)^{1/2} \quad \ldots (30c)$$

Flow of Water: $$Q = 53.4K\left(\frac{H}{L}\right)^{1/2} \quad \ldots (31c)$$

Flow of Steam: $$W = 85.2K\left(\frac{Pw}{L}\right)^{1/2} \quad \ldots (32c)$$

The value of K for various pipe sizes is given in the last column of Table 1. The value of the total co-efficient for the given fluids and pipe sizes is shown in Table 2, referring to the above equations.

With the aid of the following tables, the solution of the above equations is much simplified. Still, a great deal of numerical computation is required, especially when the problem involves the determination of diameters and it becomes necessary to solve a complicated equation of the 5th degree.

This fact prompted the writer to design the Slide Rule referred to for solving directly all problems involving the flow of fluids in pipes, thus eliminating all intricate mathematical computations. The details of the design and operation of the Slide Rule will appear in a latter issue.

TABLE I

Constants for Various Pipe Sizes

Nominal Size	Actual Diameter	$\left[1 + \frac{3.6}{D} + .03D\right]^{1/2}$	$\left[\frac{D^5}{1 + \frac{3.6}{D} + .03D}\right]^{1/2}$
½″	.622	2.611	0.117
¾″	.824	2.323	0.265
1 ″	1.049	2.113	0.532
1¼″	1.380	1.916	1.171
1½″	1.610	1.813	1.816
2 ″	2.067	1.674	3.675
2½″	2.469	1.592	6.015
3 ″	3.068	1.504	10.94
3½″	3.548	1.462	16.23
4 ″	4.026	1.419	22.95
5 ″	5.047	1.369	41.75
6 ″	6.065	1.333	68.00
8 ″	7.981	1.300	138.5
10 ″	10.020	1.288	246.8
12 ″		1.288	387.5
14 ″		1.295	567.
16 ″		1.306	785.
20 ″		1.334	1340.
24 ″		1.368	2065.
30 ″		1.421	3470.
36 ″		1.477	5265.

TABLE 2

Co-efficient of Discharge for the Given Fluids and Pipe Sizes.

Nominal Size	High Pressure Gas.	Low Pressure Gas.	Water	Steam
	66.5K	3,550K	53.4K	85.2K
⅛″	7.80	416	6.25	10.00
¾″	17.65	906	14.20	22.50
1 ″	35.40	1,890	28.40	45.30
1¼″	78.	4,160	62.50	100.00
1½″	121.	8,450	97.00	155.
2 ″	245.	13,070	196.50	313.
2½″	400.	21,380	321.00	512.
3 ″	728.	38,930	585.	933.
3½″	1,082.	57,700	868.	1,384.
4 ″	1,530.	81,500	1,228.	1,955.
5 ″	2,780.	148,400	2,235.	3,560.
6 ″	4,525.	241,800	3,630.	5,790.
8 ″	9,225.	492,500	7,400.	11,800.
10 ″	16,420.	877,500	13,200.	21,000.
12 ″	25,800.	1,377,000	20,700.	33,000.
14 ″	37,700.	2,016,000	30,300.	48,300.
16 ″	52,250.	2,790,000	41,800.	66,800.
20 ″	89,250.	4,760,000	71,600.	114,200.
24 ″	137,500.	7,340,000	110,500.	176,000.
30 ″	231,000.	12,350,000	185,500.	296,000.
36 ″	350,500.	18,700,000	281,500.	448,500.

THE EFFICIENCY OF THE INTERNAL COMBUSTION ENGINE

BY DANIEL ROESCH

Associate Professor of Gas Engineering, Armour Institute of Technology.

The efficiency of an internal combustion engine can be defined as its fuel consumption per unit power.

The graphical representation of this characteristic involves essentially two variables in the case of the speed governed stationary type, and essentially three variables in the case of the variable-load, variable-speed automatic type of engine.

Engines of the first type may have their fuel consumption characteristic represented as ordinates and the power developed as abscissa, since the speed remains approximately constant. The ordinate scale may be:

(a) Total fuel per hour (weight or volume).
(b) Total fuel per hour (B. t. u.).
(c) Fuel per B. h. p. per hour (weight or volume).
(d) Fuel per B. h. p. per hour (B. t. u.).
(e) Thermal efficiency (per cent).

The abscissa scale may be:

(a) I. h. p. developed.
(b) B. h. p. developed.
(c) Per cent of rated load.

Efficiency curves plotted to the various ordinate scales and to the B. h. p. abscissa scale for an engine of this type are shown in Figure 1.

Engines of the variable-load, variable-speed type are frequently tested at wide open throttle for maximum power and efficiency. These results can be graphically shown as in Figure 2. The gasoline consumption in pounds per brake horse power per hour is represented by ordinates, and the speed by abscissa. The (a), (b), (c), (d), or (e) methods mentioned above for constant speed engines would be applicable to this test. However, since the fuel is usually liquid and of approximately constant heating value per pound this characteristic is commonly represented only as indicated.

The fundamental fault in comparing engines of this class by this method is that the test conditions are seldom met in practice. The test conditions are wide open throttle, while the customary operating conditions the partially open throttle. This variation in operating conditions results in a wide variation of compression pressures and resultant efficiencies. The extent of this variation can easily be approximated by observing the intake manifold depression. These vary from a few inches of mercury or less for some of the above test conditions, to 12 or 15 inches of mercury or more for normal automobile operation at 15 to 30 miles per hour.

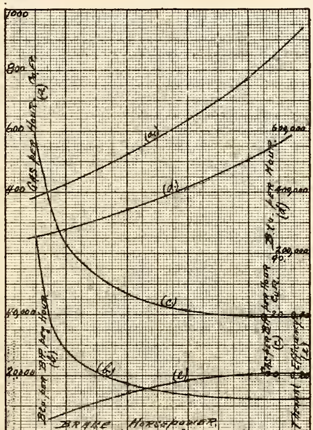
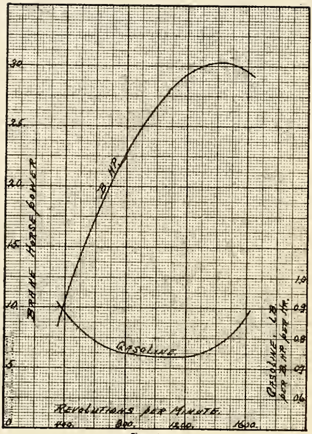
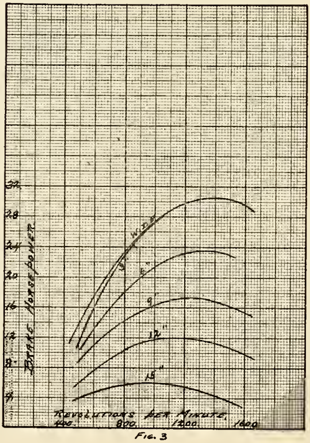


Fig. 1

Since test conditions differ widely from operating conditions the results obtained may not truly represent those obtained under operating conditions. It will be noted that the test results are meager compared to the numberless conditions of operation possible. To completely ascertain and indicate the efficiency of these engines for all ranges of load and speed, a more comprehensive method of testing and graphical representation is required. A rather critical study made of this subject in the Laboratories of the Armour Institute of Technology* gives a preference to the method herein described in detail.

*Theses: Cooban, Palmer, Stepanek—1915. Fritze, King, White—1917. Thal—1917.


Brake Horse Power
B. HP.
Gasoline
Gasoline, LB. per B. HP. per Hr.
Revolutions per Minute.
30.
25.
20.
15.
10.
5.
0
1.0
0.9
0.8
0.7
0.6
400.
800.
1200.
1600.
Fig. 2


Brake Horse Power
Revolutions per Minute.
32.
28
24
20
16
12
8.
4
400.
800.
1200.
1600.
12"
15"
Fig. 3

A conventional wide open throttle test is first made upon the engine at all speeds desired and the curves constructed. This is a true measure of the engine's characteristics under wide open throttle. The engine is then operated at a manifold depression of 3 inches of mercury (or preferably 27″ Hg. absolute pressure) and at all speeds within its test range. Subsequent series of runs are then made at manifold depressions of 6, 9, 12, 15, and 18 inches of mercury.

The results of these tests are as indicated in figure 3 for the horse power and figure 4 for the efficiencies. Figure 4 shows a

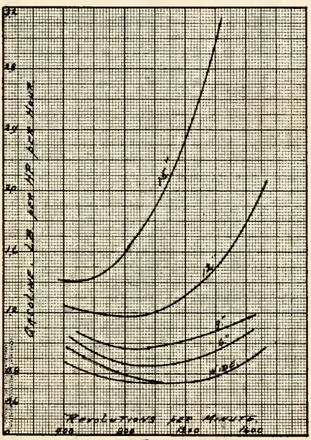


FIG. 4

decrease of thermal efficiency with an increase of manifold depression, or with a decrease in compression. This condition is not always present. There may be a slight increase in thermal efficiency per brake horse power with slight increase in manifold depression. This always followed, however, by results as indicated.

INTERPRETATION OF TEST RESULTS.

The curves in Figs. (3) and (4) are used to construct a set of interpolation curves shown in Fig. 5. Each of these curves represents the efficiencies for various loads and a constant speed

and are therefore similar to the results of test data obtained from class (1) engines. The method of obtaining the points for one of these constant speed efficiency curves is as follows:

Assuming a 500 R. p. m. curve is desired, we take the fuel consumption for wide open throttle condition and 500 R. p. m. from Fig. 4 and the corresponding B. h. p. at 500 R. p. m. and wide open throttle from Fig. 3. This locates one point on the desired curve of Fig. 5. Similar points are obtained from the

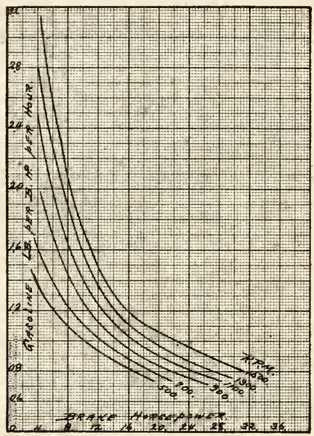


Fig. 5

economy at 6, 9, 12, etc., inch manifold depression (Fig. 4) and B. h. p. at 6, 9, 12, etc., inch manifold depression (Fig. 3). This provides sufficient points to determine the 500 R. p. m. curve of Fig. 5. The higher speed curves are then obtained in a similar manner.

SUMMARY RESULTS.

A final set of curves showing the relationship between speed, power, and economy can now be constructed as in Fig. 6.

It is to be observed that in Fig. 5 each of the constant speed curves cuts a given fuel per brake horse power per hour. If we take the 0.8 pound per brake horse power ordinate we find that it cuts the 500 R. p. m. line at 16.5 B. h. p., the 700 R. p. m. line at 19.0 B. h. p., etc. All points of load and speed having a fuel consumption of 0.8 pound are plotted on B. h. p. vs. speed chart

and a curve constructed. This represents a line of equal thermal efficiency. Other similar lines can then be constructed to show completely the efficiency of the engine tested under all conditions of load and speed. Fig. 6 represents such contour lines.

This method of analysis and a previously described method* by the writer can also be graphically represented by a surface since the relationship of three variables is desired. Surfaces

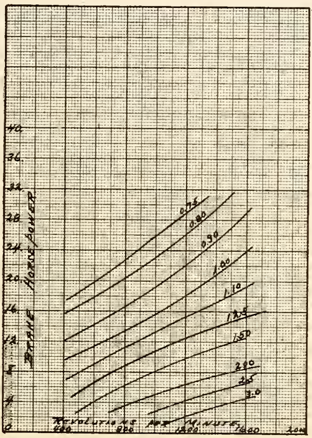


Fig. 6

used to represent the relationship between three variables are found in various engineering studies. One of the most common is the P V T surface of thermodynamics. On the other hand we have contour lines of equal barmoetric pressures familiar to all in the Weather Bureau Reports as being an example of the use of contour lines to represent the relationship of three variables.

The application of the above method to show other characteristics of the variable-load, variable-speed engine has already proven valuable along the following lines other than thermal efficiency.

(1) Mechanical efficiency. (3) Jacket water loss.
(2) Spark advance. (4) Exhaust losses.
(5) Carburetor mixture proportions.

*S. A. E. Bulletin, January, 1917, p. 360.

THE GARBAGE REDUCTION PLANT OF COLUMBUS, OHIO

BY JOHN J. SCHOMMER

Instructor of Industrial Chemistry, Armour Institute of Technology.

Through the aid of Alderman Chas. E. Merriam of Chicago, and through the courtesy of Mr. T. Banks, Superintendent of the Garbage Reduction Plant of Columbus, Ohio, I was granted the privilege, in February, 1915, of inspecting the reduction plant and examining its books for the year of 1914.

In the year of 1914 the estimated population of Columbus was 205,000. To handle the garbage from this number of people the following were built:

1. A green garbage or unloading building; 45 ft. wide and 85 ft. long and about 30 ft. high.

2. The main building contains the reduction machinery, including digestors, roller presses, grease separating tanks, refining and storage tanks, drying equipment and evaporators. It also contains the boiler plant, machine shop and water supply pumps. The part containing the digestors, presses, dryers and storage rooms is three stories high and the other part one story high.

This building covers a space of 80x167 feet.

3. A small office building.

4. A small stable.

The main and the unloading buildings are constructed with concrete floors, steel floor beams, and steel columns. The walls consist of hard impervious bricks, and the roofs of hollow terra-cotta book tile on which is laid a composition roof.

These four buildings with a chimney 150 ft. high and 6 ft. in diameter, constitute the reduction plant which is located 1½ miles south of the city.

To facilitate the handling of the garbage, 34 wagons necessary horses, 4 railway cars, a garbage loading station and stable complete the outfit. The wagons consist of a rectangular steel body mounted on gears. A canvas cover is used. A wagon has a capacity of 2½ cu. yds. and the weight of garbage varies from 1½ to 2 tons. The garbage cars have a capacity of 40 tons and hold 1400 cu. ft. of garbage. The cars are of steel and of a semi-circular body set on trunnions so they may be turned to

discharge the load. The loading station consists of a brick building 90x40 ft. and 2 stories high, and has space enough to handle the loading of two cars (simultaneously). An incline driveway 15 ft. above the track permits the dumping of the garbage from the wagons into the cars. The stable is two-story brick building 60 ft. wide and 200 ft. long and has a capacity of 106 horses.

The garbage is collected at night by wagons and dumped in the cars at the loading station in town. From here the cars are hauled by train to the Green Garbage or unloading building at the reduction plant.

The percentage of grease and tankage per ton of Green Garbage is as follows:

Grease	2.744%
Tankage	8.100%
Total solids	10.844%

Handling.

The garbage when delivered at the plant is weighed on railway track scales and then run into the Green Garbage Building on a railway siding which extends through it. The body of the car is then turned on trunnions by means of power hoists and the contents of the car discharged onto the floor below. The free water is drained off through a gutter, covered with perforated plates, extending the full length of the building. The swill water from the gutter is drained into a catch basin from which it is discharged into the grease separating tanks after which it is evaporated. The garbage is sorted and shoveled into a 24-inch scraper conveyor which extends the full length of the Green Garbage Building.

Connecting the Green Garbage Building with the Main Building is an incline truss which carries the conveyor to the top of the building and then along the bottom chord of the roof trusses and over the tops of the digestors. Connecting the conveyor with the digestors are swivel spouts which discharge the garbage directly into the digestors.

Digestors.

The digestors are eight in number. Each digestor is seven feet in diameter by fourteen feet long, constructed of flanged steel 5/8 inch in thickness and having a capacity of from 10 to 12

tons of garbage. The inside is lined with cement and tile of silica brick 1½ inches thick so as to protect the digestor from wear, due to the agitating of the gritty material when boiling, and at the same time to resist the action of the acids which would attack the metal. At the top of each digestor is an 18-inch diameter cast iron inlet door and frame, and on the bottom is a 16-inch flanged outlet for attaching the discharge valve.

The outlet castings are tapped on the opposite sides for pipe connections through which live steam is admitted for cooking. The steam is turned into both connections at the same time and as the discharge from the steam nozzles comes together the steam spreads and circulates through the mass. The top of each digestor is connected by a brass vent pipe to a condenser. When cooking, the steam is allowed to escape through a ¼ inch by-pass so as to insure against the digestor becoming airbound and thus prevent the steam from entering.

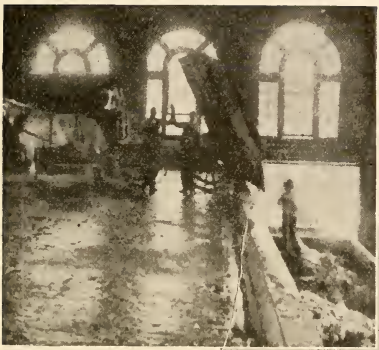
The digestors are arranged in nests of four and are connected to a common receiving hopper by a large gate valve and nozzle on the bottom of each digestor. When cooked the garbage is discharged through the large valve into the receiving hopper which is directly connected to a roller press. The four digestors, one receiving hopper and a roller press being called one unit.

The vapors which arise from the mass when dropped into the receiving hopper are conducted by a vent line to a condenser, which with the condensers for the digestors, is connected to a vapor tight steel hot well. Any odors that are carried by the gases and not taken up in the condensers are trapped in the hot well and then passed by vent line to the boiler furnace.

The time required in cooking varies with the quality of garbage but averages from six to eight hours with the steam at from 60 to 70 pounds gauge pressure as it enters the digestor.

Presses.

The presses which are connected to the receiving hopper are of the continuous roller type and were designed by Mr. Charles Edgerton, especially for handling garbage. The presses are constructed throughout of cast iron, wrought steel and cast steel with renewable wearing strips, takeup boxes and cleaning brushes. Each press is enclosed in a vapor tight cast iron housing approximately 28 feet long 3 feet wide and 7 feet high. The



Unloading Garbage at Loading Station

Sorting Floor in Unloading Building

presses are directly connected to the bottom of the receiving hoppers so that the material from the digestors passes through the press before being exposed. The press is provided with an upper and lower conveying apron. The upper apron is made up of ½ inch steel slats riveted to a heavy forged steel chain. The upper apron acts as the bottom of the receiving hopper and when the press is running carries the material through the feeding rolls and discharges it on to the lower apron. The lower apron is composed of perforated slats ⅜ inch in thickness and riveted to a forged steel chain of the same character as that used in the upper apron. The lower apron passes through between six cast iron rolls arranged in pairs. The rolls are 28 inches in diameter and controlled by heavy steel springs so that they may be regulated to any desired pressure depending on the quantity of material to be passed through. The pressed material is discharged at the front of the press into a scraper conveyor which carries it to the second floor of the drying department.

The press is driven by a belt from a counter shaft which in turn is driven by a 7½ horse power motor directly connected by a spur gear. The pressing rolls are driven by chains and the press constructed so that one apron, or both, can be operated at the same time. On the feeding roll is a safety device to protect the press should any foreign substance get back of the roll, which is too large to pass through or too hard to be crushed by the rolls. The press can be reversed so as to remove any material if desired from under the rolls.

Grease Separator

The water and grease flow back from the press through a covered conduit to the catch basins in the grease separating room. The catch basins are below the floor and in the bottom of each is a small centrifugal pump which is driven by a vertical motor. The water and grease are pumped from the settling basins into a battery of tanks where the grease is separated by gravity. The separating tanks are six in number and connected in series by an eight-inch by twelve-inch opening near the top. The grease rising in the first tank overflows into the second and from the second to the third and so on through all the tanks with the largest amount of grease collecting in the sixth tank

from which it is drawn off by means of a pipe line into one of the two treating tanks. Each tank is seven feet in diameter and twelve feet long and constructed with a flat top and conical bottom.

The grease drawn off from the separating tanks is heated up in the treating tanks, in order to separate the impurities, and then pumped into storage tanks ready for shipment. The grease storage tanks are four in number with a total capacity for storing 15,000 gallons of grease. The storage tanks are so piped that the grease can be pumped into any one of the tanks or be drawn off and discharged into railway tank cars for shipment.

Tank Water.

The liquor as it comes from the presses carries more or less solids in suspension. These solids are known as muck and silt. The muck settles to the bottom of the tank and the silt rises to the top of the water just below the grease. By means of pipe connection the muck and silt are drawn off by a magma pump and discharged into a muck tank which is similar in design to the separating tanks. The solids from the muck tank are placed in a screw press from which the liquor flows to the catch basins and the solids are placed in the conveyor leading to the dryer room.

The tank water after the grease has been separated is drawn off into a large tank outside of the building. The first and sixth separating tanks are provided with a large control valve so that the liquor can be raised or lowered to any desired height in the tanks. The tank water from the last separating tank is drawn off about four feet from the top and so piped as to trap the grease. This allows the liquor to be pumped into the tanks continuously with only the tank water flowing to the storage tank leaving the grease to be drawn off as desired into the treating tanks.

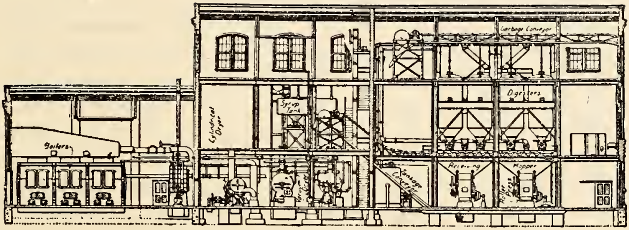
Evaporator.

The tank water from the storage tank goes to a triple effect evaporator so as to recover the five to seven per cent of solids in solution. The evaporator is made up of three round bodied cast iron pans, eight feet in diameter and built especially for the condition to be met in handling garbage tank water. All the parts that come in contact with the liquor are made extra heavy

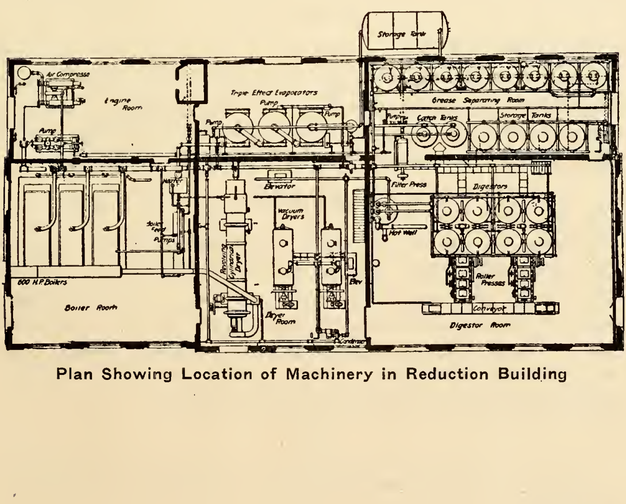
and the third pan is made with a special bottom for removing the solids that accumulate. The total heating surface in the three pans is 2554 square feet and made up of No. 14 old gauge brass tube 1¼ inches in diameter. The tubes are placed horizontally and secured in position by means of gaskets and packing rings. The evaporator is capable of concentrating 1500 gallons of tank water per hour from 7 degrees Be. to 22 degrees Be. using exhaust steam at five pounds pressure and a vacuum of 25 inches on the third pan. By use of the round bodies all internal bracing is discarded and the pans constructed with fewer joints. Each effect is equipped with an internal separator to prevent extrainment, manhole, vacuum breaker, vent pipe, four peep holes, internal electric light and the necessary gauges. The condensation is handled by condensation pumps and the concentrated syrup is drawn off by magma pump and discharged into a storage tank on the second floor of the drying department. The feed pump to the evaporator is provided with a neutralizing gear and connected to a tank containing a neutralizing solution. By means of the neutralizing gear the required amount of solution is mixed with the tank water to neutralize the acid so as to prevent it attacking the metal. The vacuum is maintained by an 8x12x12 condenser pump of the injection type.

Dryers.

The solids from the roller presses after they are delivered to the drying department, are fed into a revolving cylindrical dryer. This dryer is constructed with a steam jacket and the inner shell is provided with lifting angles in short lengths arranged so as to have free expansion and contraction. The lifting angles carry the material well up on the rising side of the dryer. The heat for drying is obtained from the steam jacket and radiator coils which are at the discharge end of the dryer. A small cast iron blower is connected to the rear of the housing and when running discharges air through the coils and then into the shell of the dryer. At the feed end of the dryer is placed another cast iron blower which exhausts the saturated air and discharges it through a condenser tower and then to the boiler flue. The material to be dried is fed into the dryer continuously and discharged by means of a short spiral conveyor at the opposite end. The material passes through the dryer due to the cylinder



Longitudinal Section Through Reduction Building



Plan Showing Location of Machinery in Reduction Building

being set on an incline. The shell revolves on trunnions and is driven by a 10-horse power motor directly connected by spur gearing.

The dry material from the revolving dryer is then elevated to the second floor and passed through a revolving screen. The screened tankage is then placed in the vacuum or mixing dryers and the concentrated syrup from the evaporator is added. The dry fibrous material acts as a filler and enables the moisture in the syrup to be driven off. The addition of the syrup to the fibrous tankage produces a higher grade of tankage from a mechanical and fertilizing standpoint. The vacuum dryers are two in number and constructed with a two-inch steam space between the outer and inner shell. The dryers are 15 feet long and 60 inches in diameter. Through the center of each dryer is a shaft to which paddles are attached for agitating and mixing the material. When dry the material is discharged from the dryer into a spiral conveyor. The spiral conveyor is connected to an elevator which discharges the tankage on to the third floor where it is stored until shipment.

Percolating Plant.

The city has now built a percolating plant to extract grease from the dry tankage as only about one-half of the available grease is recovered by means of the press. The percolating plant consists of extractor, vaporizers, condensers and storage tanks and is located in a small building just west of the Main Building.

Power Equipment.

The electric current for both lighting and power is furnished by the Municipal Light Plant at a cost of 1½ cents per kilowatt hour. An independent motor is connected with each power driven unit and operated with 440 volt, 60 cycle, 2 phase current. The boiler plant consists of three horizontal tubular boilers 78 inches in diameter by 20 feet long. Two of the boilers are in regular service and the third is in reserve.

Cost.

The cost of the Collection Equipment and Reduction Plant was as follows:

Collection Department.

Loading Station site	$ 10,136.40
Loading Station	14,101.64
Collection Stable	41,796.55
Trestle and driveway	2,153.10
Grading, fill, electric wiring	2,379.54
Garbage cars	7,564.00
Garbage wagons	7,151.10
Railway siding	3,161.60
	$88,443.93

Reduction Plant.

Levee	$ 9,711.72
Building, grading, etc.	81,267.05
Reduction machinery	59,866.00
Power equipment	21,356.70
Railway tracks	3,342.80
Conveying machinery	9,316.22
Electric wiring	3,670.99
Non-Conducting covering	1,010.75
	$189,542.23

Miscellaneous.

Office and advertising	$ 1,401.18
Engineering	16,143.48
	$17,544.66
Total	$295,530.82

Table below shows the Garbage collected monthly:

	1914 Total Tons	Average Tons Per Day
January	1,504.06	55.71
February	1,112.20	46.34
March	1,402.81	53.95
April	1,552.73	59.72
May	1,627.12	61.91
June	1,817.47	69.90
July	2,093.81	77.55
August	2,263.93	87.07
September	2,614.47	100.56
October	2,283.42	84.57
November	1,740.77	66.63
December	1,616.18	62.16
Total	21,628.97	69.32
Total days		312

Number of dead horses, 173.
Number of other animals, 10.
Estimated population, 205,000.
Garbage per capita, 211 pounds.

Expenditures.

Supervision	$ 4,262.50
Firemen	2,670.03
Labor for repairs	2,190.27
Operators	4,760.79
Ordinary labor	10,600.53
Coal	6,907.01
Electric power	1,453.05
Maintenance supplies	3,909.21
Materials for repairs	3,497.96
Renewals	792.09
Office Expenses:	
Forms and printed letters	66.55
1913 Reports	5.00
Stationery, ink, etc.	32.60
Stamps	30.00
Telephone	65.81

Towels and soap	13.26
Gas	38.10
Advertising	34.30
Typewriting Spec. and Contracts	56.86
Sample cans	11.88
Miscellaneous	30.61
Analytical work	204.75
Transportation	709.88
Miscellaneous	182.73
New Equipment	1,416.09
	$43,941.86

Receipts.

	Quantity	Value
Grease, lbs.	1,198,985	$51,128.71
Tankage, tons	1,665.19	12,479.84
Hides	148	726.70
Total		$64,335.25

Actual Cost of Operation Per Ton Garbage.

1914.

	Total	Per Ton
Supervision	$ 4,262.50	$0.197
Fireman	2,670.03	.123
Labor for repairs	2,190.27	.101
Operators	4,760.79	.220
Ordinary labor	10,600.53	.490
Coal	6,777.01	.313
Electric power	1,453.05	.067
Gasoline	2,361.60	.109
Maintenance supplies	981.66	.045
Materials for repairs	1,973.18	.091
Renewals	792.09	.037
Office expense	300.71	.014
Analytical work	204.75	.010
Transportation	709.88	.033
Miscellaneous	182.73	.009
	$40,220.78	$1.859

Quantities Consumed.

Article	Quantity	Per Ton Garbage
Coal	4,850 tons	$0.024
Elec. Power	96,870 kw. hrs.	4.480
Gasoline	19,119 gals.	0.884 gal.

Revenue per ton garbage $3.085
Cost of operation per ton garbage 1.859

Profit per ton garbage $1.226

Total Net Profit $26,501.57.

Percolator charges:
Production 233 tons grease $20,154.50

Cost of Operations.

Supervision	$ 532.80	
Labor, 312 days	1,450.80	
Coal, 700 tons at $1.39 per ton	975.10	
Gasoline, 19,119 gals.	2,361.60	
Repairs and supplies	150.00	
Total	$5,470.30	
Profit		$14,684.20

Revenue per ton garbage $0.932
Cost of operation 0.253
Profit per ton garbage 0.679

The books at the plant show total net profit of $26,501.57 for the year 1914. However, that is hardly fair to assume. No interest for money invested nor money for depreciation was charged off.

THE MIPGAMETER

THE MILES-PER-GALLON METER

BY GEORGE E. MARSH

Assistant Professor of Electrical Engineering, Armour Institute of Technology.

The mipgameter (MIles-Per-GAllon-METER) is a device that measures the efficiency of any liquid fuel motor or motor vehicle, simply, accurately, at any time and under any conditions. The steam engine has its indicator and the motor car its mipgameter, but the latter holds a closer relation to its prime mover than the former does to the steam engine. When used with a motor car, the reading is in miles per gallon and when applied to a stationary engine the reading is in revolutions per gallon. In this last mentioned case, the measurements when obtained with equal energy demands, that is, equal loads, are in the same ratio as the efficiencies.

In one type of mipgameter when applied to a motor car, the measurement may be taken from the wheel of the car in miles-per-gallon or from the shaft of the motor in revolutions-per-gallon. With the first arrangement, we have a measure of the efficiency of the motor car and in the second, the efficiency of the motor itself.

The mipgameter consists of two parts, each simple in construction and operation. An understanding of the manner in which the measurement is made will be clear from the figures, which are taken from one of the sheets of the patent specifications, and the description that follows:

The indicating part consists of a gear 12 driven by the worm 13 and flexible shaft 15 from the wheel of the motor car or truck after the usual manner of a speedometer. This gear is shown in section in Fig. 2, and carries a magnetizing coil in a recess and has electrical connections as indicated. The gear is thus an electromagnet. The armature is an iron disc 23, loose on shaft 11, and carries a pointer 24. When the circuit is closed the armature is attracted and rotates with the gear, and the pointer moves over the scale, 25. By suitable calibration the reading on the scale may be given in miles

Fig. 1.

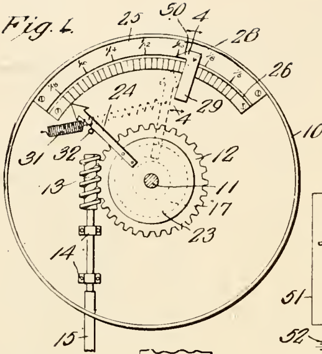


Fig. 2.

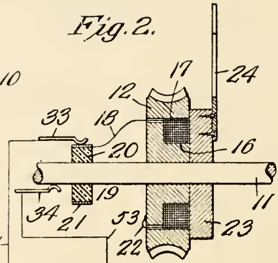


Fig. 3.

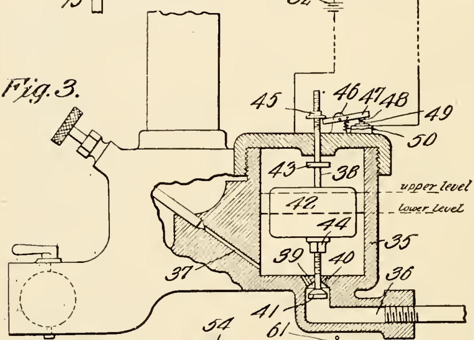


Fig. 4.

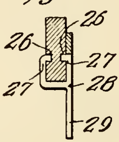
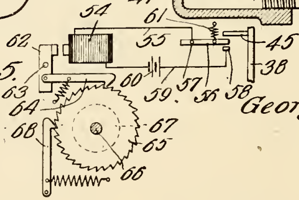


Fig. 5.



INVENTOR
George E. Marsh,

and when so operated this part of the mipgameter constitutes an odometer or milemeter, up to the limit of the scale.

A sliding marker with an index 30 is pushed along by the pointer and records the position of the pointer latter at the moment the circuit is broken, the armature released and the pointer returned to the zero position against the pin 32 by the spring 31.

The other part of the mipgameter is shown in Fig. 3, and represents the principle of operation in the simplest form. To secure greater precision under running conditions the construction is modified from that shown in the drawing, but the principle remains the same. A float 42, loose on the stem 38, follows the level of the fuel in the chamber 35, that is inserted in the supply line from the tank to the carburetor, the latter taking its supply at any rate that it may require and operating as in the usual case. As is apparent, the circuit is broken whenever the level of fuel sinks a certain amount, as say, a pint. Assuming the car has gone 1.5 miles in this time, that is 1.5 miles on a pint, the pointer will read the equivalent in Miles-per-gallon or 12. The scale is clearly one of uniform divisions and by construction or calibration its readings may be had in any units of distance and volume. The frictional index will clearly record the maximum efficiency attained between its resettings to zero.

Bearing in mind that the gear can be driven either from the wheel of the car or from the shaft of the motor, and either miles-per-gallon for the car determined or revolutions-per-gallon for the motor, found, it is seen that the efficiency of the motor car, of the motor with and without load, and of the transmission may all be made known.

The readings of the mipgameter enable the motorist to compare the efficiencies of the car and of the motor from week to week, month to month and year to year; to also obtain the comparative efficiencies at different speeds, on various roads, etc. The one adjustment of the carburetor that secures the maximum efficiency under a given set of conditions is readily ascertained. From every angle the guide to correct and perfect operation of the gasolene motor is found in the mipgameter.

We have also to mention the application of the mipgameter to factory testing and this whether the energy efficiency or a brake horsepower is the object sought. In either case the mipgameter may be calibrated and operated to give the results directly on the scale. Various printing and graphical recording forms have also been designed and patents and in some of these the efficiency is correlated with the corresponding speed.

We have briefly mentioned the chief applications of the mipgameter and have indicated the various measurements and kinds of information that become known through its use. There are others that will undoubtedly suggest themselves as the capabilities of the instrument become known. That the mipgameter bids fair to assume a highly valuable role in the attainment and maintenance of efficient motor operation seems certain, and that it fulfills the requirements of such an instrument as judged by principle, simplicity and moderate cost, is acknowledged by motor-car engineers.

GENERAL DUTIES AND WORK OF THE MILITARY ENGINEER

(*Abstract from Major Bond's Series of Articles on National Defense for Engineer and Contractor, Engineering Record, March-April,* 1916.)

BY MAJOR P. S. BOND*
Corps of Engineers, U. S. Army

The duty of the military engineer in time of war is to plan and execute all works of an engineering nature which are required in connection with the operations of the army. It will be apparent that this is a wide field of endeavor. The engineering requirements of any army include most of those of the average large community, and in addition many others not called for by the gentle vocations of peace. The military engineer must have, therefore, a thorough working knowledge of the more important branches of civil, mechanical and electrical engineering as applied to military needs. This might appear to be more than an average man could be expected to know, and so it would be, did we demand of the military engineer all the precision and nicety characteristic of civil practice. Military engineering, in rather sharp contrast to good civil practice, is characterized by makeshifts and temporary expedients. "Build for posterity," says the civil engineer. He places the foundations of his bridge at great expense of time and labor on the solid rock and he has a just pride in the enduring nature of the structure he erects. In his brain is the accumulated knowledge of centuries of painstaking construction. Long after his death the great bridge remains, a monument to his skill and devotion. How different is the case of the military engineer. Not for posterity builds he, but for the exigency of the moment. Not on the solid rock does he place his foundation, but often on the heaving bosom of the stream itself. The army

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arrives at the impassable stream and the engineer rapidly scans the situation. In his brain also is the accumulated knowledge of centuries of scientific warfare. Alladin's lamp is rubbed. And lo! in the twinkling of an eye the wonderful bridge is there and the army with all its animals and heavy vehicles proceeds across. To the frail but still adequate structure are committed not only the lives of the troops, but the destinies of the nation perhaps.

The military engineer must possess not only a thorough knowledge of construction, but also a thorough knowledge of the art of warfare. He must foresee the needs of the army and build to meet those needs, and on his sagacity, energy, foresight and resourcefulness the issue of the campaign may indeed depend.

The duties of engineer troops in the United States Army in time of war may, with respect to location, be classified as follows:

1. At bases, mobilization camps and advance supply depots.
2. On the line of communications.
3. In the attack and defense of fortified places (siege operations).
4. With the mobile army in the field.

Each of these is further capable of subdivision and may include a great variety of works. Duty with mobile army is the prime function of engineer troops, and is the one on which their operations, training and equipment should primarily be based. All other engineering duties, except, possibly, siege operations, must be regarded as special. They will, when necessary, be performed by engineer troops, either regular or volunteer, with such changes or additions in personnel or equipment, civilian assistance, etc., as the special situation or exigency may demand.

ENGINEER OPERATIONS CLASSIFIED.

The engineer troops for field service should be with the combatant forces at the front, at all times subject to the immediate orders of the commanders of the divisions or armies to which they may be attached. Their duties will be intimately connected with the movements and tactical operations of the fighting forces and should be characterized by extreme rapidity,

full use of local resources and a thoroughness all sufficient unto the immediate needs, but *no more* than sufficient. Subject to these conditions, the operations of the field engineers may be roughly classified as follows:

1. Operations to facilitate the rapid movement of the combatant forces.

2. Operations to increase the offensive or defensive powers of the combatant forces and to limit or decrease those of the enemy.

3. Operations to maintain the health and promote the comfort of the troops.

In brief, these duties may be classified as, (1) transportation; (2) fortification; (3) sanitation—in short, conserving and promoting the operating efficiency of the troops.

It is of the utmost importance in every case to draw the line of demarcation between the duties of the field engineers at the front and those which properly pertain to the engineer or other personnel on the lines of communication. This is necessary in order to insure smooth co-operation and the presence in every tactical emergency of the mobile engineer troops with the combatant forces. The supreme commander in the field will in each case prescribe and limit the functions of the two organizations. Those of the field engineers should include no work which might have been performed by others. There will be enough which they alone can execute, and their energies should not be frittered away on work for which other troops or civilians are or might be made available.

The more important special duties of engineer troops in the mobile army may include:

1. Reconnaisance of the natural and cultural features of the terrain, preliminary to tactical operations, or for other purposes, and reconnaissance of hostile works and depositions.

2. Collection of maps and other data from local sources.

3. Correction and amplification of existing charts.

4. Mapping of limited portions of the terrain within the sphere of tactful operations and other minor survey duties.

5. Map reproduction, field methods.

6. Collection and utilization of local engineering resources in personnel and material.

7. Laying out of defensive positions and points of support.

8. Planning and superintending of offensive or defensive field fortifications, including obstacles, sapping and mining, etc., and the execution of the more difficult tasks in connection therewith.

9. Laying out and improving camps.

10. Sanitation, including water supply and sewage disposal.

11. Construction of and repair of roads, railroads and bridges.

12. Construction of temporary buildings and repair of permanent buildings and other structures.

13. Military demolitions.

The engineer troops are those prepared to execute all tasks which may be assigned them, and the engineers of the United States Army are trained with this end in view. In the field they must not only meet but anticipate the needs of the army. To this end the chief engineer should be at all times in close touch with the commander-in-chief and with the engineer troops, and each battalion and company commander of the engineers must be at all times in close touch and hearty co-operation with the troops of the line with whom he is serving.

SPECIALIZATION UNDESIRABLE

On account of the variety of duties exacted of any army in war, we find a strong tendency in many countries to specialize the work of the technical troops. By this is meant that certain organizations are trained to perform a certain kind of work and are not supposed to be employed in anything outside of their specialty. Thus, we find in the European armies sapper companies, railroad companies, etc. One foreign engineer has even recommended the organization of water-supply companies.

In our own service the duties of the foreign aero and telegraph companies fall to the Signal Corps. All the remaining technical field operations demanded by the modern army are to be performed by the engineers—an entirely feasable arrangement. If we were to have special troops for each technical duty there would be no limit to their numbers. Moreover, many of these duties are sporadic in their nature and the troops trained to perform them would necessarily be idle a large part of their time, or else, which is more probable, they would be

assigned to other duty, for which they should have been trained. So far as our own service is concerned, a multitude of special troops would be a useless expense, and our engineer companies can and should be trained to perform satisfactorily all the engineering operations required by the mobile army, including the mapping of limited portions of the terrain, the construction of temporary buildings, water supply, the hasty repair of railroads, etc. A single organization large enough to have a representative with every command, from a brigade up, is thus always available and qualified to perform any task that may be assigned. Extensive work of a special nature, excepting siege operations, will generally be executed in the rear of the army, and special provisions therefore can be made as the occasions arise.

QUICK RESULTS ESSENTIAL.

Military engineering, as we have seen, is an adaptation of civil engineering to military needs. The fundamental difference between the two arts is their economic aspects. In civil engineering the element of first cost is of prime importance. The matter of time consumed in construction is of importance as a rule only as affecting the first cost and the financial returns on the investment. A considerable time spent in design and other preliminaries to construction will usually be amply justified by a material saving in first cost.

Such are the economics of civil engineering. Those of military field engineering are very different. The cost of a modern war between two great nations is enormous—estimated at about $100,000,000 per day, not including incidental losses to industry and commerce, for all the European belligerents. The price of success is great enough—that of failure is usually much greater. A few days—even a few hours—have decided the issue of a battle and the fate of a nation. Accordingly, the march of events is rapid in modern warfare. Everything must move with the utmost celerity. Time is the controlling element. The commanding general does not ask his engineer, "How much will it cost?" but "How soon will it be ready?" The rough and ready makeshifts which serve their purpose are the triumphs of the military engineer's art. They have the beauty of utilitarianism.

USE ANY MATERIAL AT HAND.

Suppose that it is war time and an army approaches a stream. Its mission is to cross the stream and seize an important position on the other side before the enemy can reach and hold it. The engineer with this force is called upon for a bridge to replace the one that has been unexpectedly destroyed. "It must be ready by day after to-morrow," the Commanding General informs him, "or my opportunity will be lost." Unlike the civil community, the army cannot wait for its bridge. The engineer finds that no suitable lumber is at hand, but he perceives a number of costly buildings whose demolition will furnish what he needs. The owners protest their destruction. The engineer is well aware that they will place claims for many thousands of dollars against the government, but he realizes the vital need for the bridge and rightly considers the cost as insignificant by comparison. He is not restricted to the available funds of a small community but has at his back the vast resources of a great and wealthy nation which demands results. The buildings are demolished in spite of protest, and the bridge is built on time. The army accomplishes its mission, which proves to be a contributing cause of ultimate victory.

The two chief essentials of military field engineering, then, are: (1) The adaptation of engineering work to tactful needs; (2) appreciation of the economics of warfare, which ordinarily demand high speed in construction, even at a sacrifiice of money or life.

Only the simplest works can be successfully executed in the haste and excitement attendant upon field operations. In the forefront of operations, often actually under fire, construction can and must be carried on under conditions which would be exceedingly discouraging to the average civilian engineer or contractor. It is the simplest works, comparatively few in number, which will most frequently be demanded. It is for the execution of these simple works that engineer officers and troops should primarily be trained.

AIDS TO SPEED.

The methods by which speed in construction may be attained constitute a study which no engineers, military or civilian, can afford to neglect. Formal plans are rarely used. Ordinarily

nothing more than simple sketches are required. These consist of an instantaneous adaptation of military type plans to the materials, tools and labor available. All details which increase the time required for construction without being absolutely essential to the completed structure are eliminated and the remaining detail reduced to the simplest form. Unless a construction plant is available, which will seldom be the case, very large pieces should not be used. All pieces should be of such size that they can be readily obtained and easily handled by men with the assistance of animals and simple tackle.

It is not to be supposed indeed that all military field engineering is in the nature of sudden emergencies. Frequently, the need of certain structures can be foreseen days or weeks in advance, and when this is the case careful and elaborate preliminary arrangements may be possible.

In starting work the necessary tools are laid out and steps taken in advance to have all necessary material on hand as soon as it may be required. The work should then be divided into a number of definite tasks under the officers and senior non-commissioned officers, and these again subdivided into smaller tasks, under the junior non-commissioned officers. The cost of superintendence, which might be prohibitive on civil work, is justified in military construction if it results in a saving of time. If several of the tasks can be made similar in nature and equal in amount, so much the better. This will create competition, always a stimulus to endeavor.

It should never be necessary to have any men idle, except when they are actually resting. There always will be tasks in connection with any piece work, the performance of which will tire the men as much as standing around, which is very fatiguing. Extra non-commissioned officers should be put to work, on the more dignified tasks of course. They should not be allowed to get the idea that their sole function is to superintend. The foreman of any particular task, should, when practicable, be given a specific time in which to complete it, usually the least time in which the task can possibly be accomplished. While he may fail to complete it on time, he will naturally be anxious to avoid the explanations that will then be demanded of him. If no time is set for completion dawdling is very apt to result. Two gangs mutually dependent upon each other, as where one furn-

ishes the material which another incorporates in the structure, should be so organized that each will be hard pushed to keep up with the other. This is in the nature of competition. If the number of tools is limited, care should be taken that all tools are doing useful work all the time.

NO USE FOR HEAVY PLANT.

It has frequently been remarked that military engineers make very little use of construction plant in their field operations and they have been criticised for not availing themselves of it to a greater extent. Plant is utilized in military construction whenever practicable, but in operations with the mobile troops at the front the opportunities for its useful employment are decidedly limited in number. Such plant is, of course, less useful on the light, hasty military structures than on the heavier and more formal works of peace. The work of the military engineers is spread over a considerable area, they move rapidly from place to place, and they must at all times keep up with the mobile fighting force. Heavy construction plant is not sufficiently mobile to meet such requirements. Often it would not be on hand when needed. One of the chief purposes of such plant is to have manual labor, and of this there is seldom a dearth in military operations. The military pioneer is greatly concerned in preserving his mobility, and accordingly must not be unduly hampered in his movements by the necessity for transporting heavy machines. This is especially true in America on account of the deficiency of good roads. Therefore, he places his chief reliance on the most mobile and adaptable of all machines—man himself.

In his occupation of a defensive position, each soldier intrenches his own section of the line. It is quite apparent that the troops can be disposed in the position and can complete the excavation, each man using his own portable tool, in a few hours of time. In such a situation, trenching machines could not compete with manual labor. If concrete be employed in such intrenchments, it would be distributed in small masses over a considerable distance. Neither large nor small machine mixers would be as rapid and efficient as hand mixing.

For the more formal work in rear of the fighting forces, however, conditions will be different and plant may be more fre-

quently employed. Such works would include roads, railroads and bridges on the lines of communication, buildings at supply depots, the preparation of secondary lines of defense, the rather deliberate fortification of important cities, arsenals, supply depots, etc. Here labor will be less plentiful than at the front, more time will be available, and structures of somewhat more permanent nature will be appropriate. The intrenchments of the field army are in general located and prepared in haste and are later elaborated and developed to meet the tactful needs of the situation.

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THE ENGINEERS PERSONAL QUALIFICATIONS

Every engineer who is interested in advancing himself will naturally consider what ways and means may properly be used for this purpose. In general, such ways and means may be arranged in two groups—those which relate to personal improvement and those which may be classed as advertising in one or more of its various forms. While nothing is intended to mini-

mize the importance of legitimate advertising, the present discussion will consider only the things relating to personal improvement.

In order that one may act intelligently in an effort to better himself personally, he should know at least what qualities are desired. The engineer selling his services is similar to a merchant selling his goods, and both should know what the market demands. Fortunately, this situation has been quite thoroughly canvassed and we now have an excellent summary of the qualities wanted in engineers, by engineers.

Acting under the direction of the Carnegie Foundation for the Advancement of Teaching in conjunction with a joint committee on education from a number of the national engineering societies, Dr. C. R. Mann, has compiled a list of qualities which shows what is the demand in personal qualifications. This demand was determined from about 1400 replies to inquiries sent to engineers in all lines, asking them to name the qualities which they considered necessary for success. These replies enumerated almost every human attribute, and a condensed grouping of the essential features has been made by Dr. Mann, which we may consider as fairly representative of the whole list, and is given below:

Character, integrity, responsibility, resourcefulness, initiative.
Judgment, common sense, scientific attitude, perspective.
Efficiency, thoroughness, accuracy, industry.
Understanding of men, executive ability.
Knowledge of the fundamentals of engineering science.
Technique of practice and of business.

An inspection of these groups shows that the arrangement has been such that the first group contains moral qualities, mainly; the second, intellectual; the third, those things relating to a man's facility in dealing with things; fourth, the dealings with men, while the fifth and sixth, are self-explanatory. An important feature of this grouping is that it classifies a large number of different qualities and gives a better opportunity for an appraisal of one's abilities.

In addition to knowing what is desired, it is equally important to know the relative values of the various things wanted. In order to determine this, Dr. Mann made further inquiries and from about 7000 replies, attempted to rate the previously

given groups according to their value in a scale of 100. The following shows the relative values which have been assigned as the result of the second investigation.

	Relative Values
Character, integrity, responsibility, resourcefulness, initiative	24.0
Judgment, common sense, scientific attitude, perspective	19.5
Efficiency, thoroughness, accuracy, industry	16.5
Understanding of men, executive ability	15.0
Knowledge of the fundamentals of engineering science	15.0
Technique of practice and of business	10.0
Total	100.0

It is immediately apparent from the results obtained that moral qualities rank highest, while technical knowledge is one of the lowest. This, in a measure, is not peculiar to engineers, but is found in other lines of work. It is simply another way of saying that a man must be a man first, and a specialist in some other particular line second. The moral qualities furnish a foundation on which to build a reliable superstructure.

It might appear to some, that since technical knowledge, for example, is rated comparatively low, that it could, therefore, be slighted in favor of something else. It should be noted, however, that no matter how good a man may be otherwise, if he cannot make a fair grade in technical knowledge, he cannot be expected to become a good engineer, and on the other hand, if he is strong on the technical side, but weak on the moral side, he cannot expect to gain responsible positions. The relative values given for the various groups of qualities simply indicate what should be striven for in order to develop a well balanced engineer.

It may be stated further that the relative values assigned to the different groups will be influenced somewhat by the character of work which the engineer is called upon to do. Thus, if one is engaged in research work or design work, one may be weak in executive ability and strong in technical knowledge. However, if one is a superintendent or a manager, the reverse condition might exist and still have satisfactory results. The

relative values which have been assigned are therefore to be looked upon in the nature of averages for a large number of different positions.

A question which will naturally arise in such an analysis of one's personal qualities as is suggested by these groups is how far should technical education be carried? If we think of technical education as relating solely to the acquiring of knowledge of nature's laws, it would be evident that we should consider other things in order to develop a well balanced engineer. However, it will be readily admitted that a study of the phenomena of nature with the application of scientific principles in engineering work will aid in developing such qualities as resourcefulness, common sense and accuracy. A proper study of engineering science will develop other things besides adding to one's knowledge.

While this discussion is not intended as an apology, in any sense, for engineering education, it may not be out of place to point out some common-place analogies. One does not go to a grocery store to buy clothing, or to a tailor shop to get dinner. It is but natural therefore, that one wishing to become an engineer, should go to a place where things dealing directly with engineering are taught. The matters of character, judgment and efficiency are in part fixed before one is ready for engineering education, but they can also be developed during, as well as after, such a course. The qualities here presented can be used for self guidance in order that one may properly appraise his own qualifications and seek to improve them in every way in which it is possible. They simply serve as a standard to which to work and show that one set of qualities must not be developed to the exclusion of all others. A well balanced engineer must take a well balanced view of himself, as well as of the things with which he has to deal.

E. H. Freeman.

AN ENGINEERING EDUCATION AS PREPARATION FOR THE SUPERVISION OF COURSES IN INDUSTRIAL ARTS

It is with mingled feelings of hesitancy and pleasure that I enter upon this discussion; hesitancy in presuming to criticise

others of my profession, and pleasure for the incentive here afforded for the careful expression of a few definite personal ideas upon this subject. My position is not unlike that of the individual whose opinion of his mother has been requested. As it is probable that she is the best he ever had, his reply will, in all probability, be biased in her favor. If my few remarks seem dogmatic or prejudiced, they may be so because my Alma Mater is a technical school, and as I see it, one of the most exacting.

As a supervisor, my opportunity to observe the relative capabilities of teachers in the field of industrial education has been not inconsiderable and this experience, together with information I have gleaned from the remarks of conservative educators generally, would, I believe, justify their classification, according to previous education and its apparent results in the class room, into three groups as follows:

In the first group, I would place the university graduates. These gentlemen have specialized in psychology, pedagogy, history of education, social and industrial survey, and the cultural subjects generally, but their shop courses have, necessarily, lacked in comprehensiveness and have tended toward fussiness; their drafting courses have been inadequate and superficial, and their instruction in applied mathematics, science and mechanics of a similar character.

Many a cherished precept is held by them, such, for example, as "do not tell a lad to construct a certain exercise; create first the desire for the object and the work will then be done spontaneously." For these they have such respect that they move with great circumspection and the apparent results from their instruction are, therefore, not what should be expected.

Some of us believe that the presentation of subjects in, at least, three of the four years of High school should be general and suggestive, rather than specific and conclusive; that the ideal should be to show in a broad way the nature of various industrial pursuits, so that choice may be exercised intelligently by the student. This ideal, however, is far from popular with educators as a whole, and with this group in particular, for their faith in the industrial survey is great, since by its means, they believe a certain definite number of round holes, *i. e.*, plumbing jobs, carpenter jobs, machinists jobs, etc., may be found in

any given community into which they may fit an equal number of round pegs in the form of boys they have trained. We of the minority group, can see little but make-shift in this movement, for the square pegs they are forcing into round holes are always before us; boys intended for engineers, architects, chemists or any one of those great callings whose development is unlimited.

In the second group would be placed the normal industrial school graduates. The student body of these institutions is made up of men from the trades, from the high schools, from the teaching profession itself, and, in fact, from so many and such varied walks of life that the final product at graduation is far from homogeneous. The curriculum of these schools calls for thorough, comprehensive and practical shop courses, subordinate to which are those in drafting, modern languages, science, mathematics, pedagogy, and history of education. Consistently planned, these courses produce shop instructors of a very high order. Lacking, however, an intense application of the sciences and of mathematics to practical achievement, it is natural that those who have been thus trained should show a tendency to be satisfied with the immediate product to the detriment of a complete educational program.

The third and last group of teachers, according to this classification, may be made up of the graduates of technical schools.

It is, I believe, generally recognized that in no other department of education is there such intense application, such constant and strenuous effort required for success as in that of engineering. A degree from a recognized institution of this character presupposes on the part of its possessor a knowledge of the laws governing those forces to which the industries are indebted for their moving energy; an acquaintance by exact laboratory methods with the application of those forces to the ingeniously contrived mechanisms which utilize this energy so efficiently in production; a familiarity with the structure, composition, and nature of the peculiarities manifested under subjection to strain of the materials of the commercial world; and, above all, a developed resourcefulness that may be called upon to stimulate efficiency and to delight in the solving of the knotty problem wherever encountered. It would be superfluous, in this brief article, to enumerate the subjects, pursuit of which is relied

upon to produce the foregoing results. All are familiar with them and know that to omit or to slight one will surely result in a distinct loss in the effectiveness of the course as outlined.

To summarize, then, it would seem to the writer that those of the first group, while undoubtedly remarkably well prepared in the theory of the profession, lack the broad technical education that should be required of instructors entering this department of education. Apparently their training more nearly answers the requirements of general than of special supervision. Of the second group it may be said that for the manual arts, exclusively, no better course could be arranged, but that for supervision or for instruction in the departments of drafting, applied science, or applied mathematics, a sufficient foundation is not provided. The third group certainly most nearly supplies the qualities necessary for these positions, for, although lacking a thorough training in psychology and the history of education, these deficiencies may far more readily be removed by reading, by experience and by association than can the defects of the first two groups. It should also be borne in mind that the years spent under the guidance of professors of the highest qualifications can hardly fail to set an example of efficient teaching method that would out-weigh the effect of any treatise upon the subject.

It is my opinion that to be in a position to discriminate between ideas of genuine importance and mere schemes promoted to catch the public fancy, schemes, which, if carried out, would result in the antithesis of education, the instructor and the supervisor alike must be equipped with an education that is not alone comprehensive, but pertinent as well. The last two divisions of this classification seem to fulfill both requirements, the last requirement to a degree not apparent in the first division. I have found much more reticence in the expression of approval of the "industrial survey," and of the wisdom of its champions in advocating early vocational training, in these groups than elsewhere in the profession and this to me, at least, is a hopeful sign; an indication that the quality of pertinency is invaluable.

It remains only to say in conclusion, that the field of industrial education is in need of the engineer; his energy, resourcefulness, and skill will give to it a balance that is now sadly lacking. Wealth is not to be acquired in the profession, but if he can

be satisfied with a comfortable livelihood, the satisfaction of serving the public in a noble capacity will be his and the effects of his efforts to inspire and direct the young manhood of the country in their search for the vocation which nature intended them to follow will be so apparent and so far reaching that, if he is temperamentally suited to the calling, he will find a pleasure therein that will repay many times the loss in dividends that might have come from a purely selfish venture.

Robert A. Perkins.

War Activities at Armour

On April 11, 1917, representatitves of the United States infantry, navy, cavalry, and engineering corps, addressed the faculty and the entire student body of the institute at an assembly held in the Mission. Opportunities for the engineering student in the war service were discussed.

On April 12, 1917, those students interested in the military department of the U. S. government were assembled in Science Hall to hear more details from officers of the Navy department. Mr. Murfrie, of the Record-Herald, delighted the students with an interesting description of his service in the navy. Lieutenants Stevens and Meade, and a medical officer of the navy also addressed the audience. They explained clearly the details of the various branches of the service. Dean Monin was chairman of the meeting and was kind enough to ask Mr. M. Stone of the sophomore class to tell the men of his experiences in the navy. His short talk was very spicy and he insisted that "universal training and conscription are the same thing."

There are one hundred students who are willing to join the navy under the condition that they will not be held in service after the war has ceased. This petition was drawn up by Messrs. Stone, Dougherty and Fritze.

Doctor Gunsaulus has made application to the U. S. War Department for appointment as Chaplain.

Lieut. Bolte of the Armour Alumni, has organized the students for military training. He has exerted all his efforts in arranging for weekly.meetings of the individual classes for military drill. The faculty will also be organized for military drill.

It is the desire of the students of the Armour Institute of Technology to make a great effort in the field of National Patriotism.

Engineering Societies.

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

President ....G. M. Fritze
Vice-President..............R. G. Pomeroy
Secretary ....A. J. Plocinsky
Treasurer ....Harold S. White

On March 7, 1917, the second smoker of the A. S. M. E. was held at the Armour Y. M. C. A. The Senior Mechanicals have set a precedent by inviting the Sophomores and Freshmen as well as the Juniors to their Smoker. An excellent program was presented, the following being some of the numbers:

Vocal Solo by Prof. W. G. Smith.
Magical Demonstration by Mr. O. W. Armspach.
Cello Solo by Mr. Berg.
Banjo Solo by Mr. N. Huffaker.
Talk by Prof. G. F. Gebhardt.
Eats, smokes and songs.

Everyone present spent an enjoyable evening.

At the regular meeting on Wednesday evening, March 14, 1917, announcement was made of a lecture by a representative of the Builders' Iron Foundry which was to be given at a later meeting. The business meeting was closed with a few suggestions by the member upon the welfare of the organization. Mr. S. W. Thal gave an elaborate illustrated talk on "Automobile Ignition." Mr. G. M. Fritze described the Walter Tractors. He promised the members that he would have a tractor come to the school for the inspection of the Automobile Class. The meeting, a very profitable one indeed, was adjourned after assignments were made for the talks for the next meeting.

Wednesday evening, March 28, 1917, the society met as usual in the engineering rooms. It was announced that a representative of the Builders' Iron Foundry would speak on Wednesday evening, April 24, 1917. The Chairman informed the society that Mr. Isham Randolph would address the societies of Armour at a joint meeting to be held on Tuesday evening, April 24, 1917. The regular meeting of the society for that week was postponed. Mr. Taylor, one of our Juniors, gave a talk on "Thermit Welding." Mr. R. E. Marks spoke extemporaneously upon "Motion Pictures." Mr. G. M. Fritze thoroughly and interestingly discussed "Trackless Trains."

At the regular meeting on Wednesday evening, April 11, 1917, Mr. J. G. H. Jewell, of the Builders' Iron Foundry, gave an elaborate illustrated lecture on the "Venturi Meter, Its History, Development and Uses." A vote of thanks was extended to Mr. Jewell for his interesting talk. The faculty and the members of the student branch were well represented.

Although somewhat remote from the regular business of the society, a report was made on the "Preparedness Movement" at Armour. This report was sent in to the Secretary of the Student Branches of the A. S. M. E. and is to appear in the May issue of the A. S. M. E. Journal.

A. J. Plocinsky.

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Chairman .... R. H. Earle
Secretary .... H. A. Kleinman
Treasurer .... W. J. Watt

Wednesday, February 28, 1917, Professors Freeman and Dean discussed the "Lake Spaulding Hydro-Electric Development," illustrating the talk with slides from the Pelton Water Wheel Co. Professor Dean covered the hydraulic features of the plant, pointing out the items of particular interest to the civil engineer, while Professor Freeman discussed the electrical equipment.

The meeting of March 6th, was addressed by Mr. W. W. Drew, Acting Division Traffic Engineer of the Western Union

Telegraph Co., who gave a very interesting and instructive talk on the organization of the Western Union Telegraph Co. He had prepared a number of blue prints showing various departmental organizations, and also had copies of examinations given to candidates for positions as operators. The talk was very valuable and we express our thanks to Mr. Drew for his trouble and willingness to give this talk.

On March 27th, Mr. Grover, assistant to Superintendent of Substations, Commonwealth Edison Co., talked on "The Distribution of Central Station Energy Through Substations." His talk included a history of the development of substations and also a resume of the development of the Commonwealth Edison Company's system in Chicago. His talk was illustrated by slides showing examples of various installations in Chicago Mr. Grover was to have appeared at one of the meetings in February, but was detained by business and the meeting was postponed. We are very grateful to Mr. Grover and assure him that his talk was well worth waiting for.

Mr. Porges explained the operation of the Owen Magnetic transmission to the A. I. E. E. on Tuesday, April 10th. His talk was very interesting and instructive and those present felt they had learned something about the operation of this interesting device. Mr. Porges is to be complimented on the able manner in which he handled this subject.

H. A. Kleinman

THE CIVIL ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President ....A. L. Schreiber
Vice-President ....L. E. Starkel
Recording Secretary ....S. N. Miller
Corresponding Secretary.......H. W. Stride
Treasurer ....C. L. Shaw

The tenth meeting of the A. C. E. S. was held March 6, 1917, in the engineering rooms, Chapin Hall. There was some difficulty in getting a quorum, but the late arrival of one of the members completed it, and made possible the election of officers for the ensuing year. The officers elected are:

President .... Jesse Nitka
Vice-President.............. H. A. Peterson
Recording Secretary............ Leslie Weiss
Corresponding Secretary........ B. B. Cramer
Treasurer .... V. M. Brown

BOARD OF DIRECTORS

Faculty Member.......... Prof. M. B. Wells
Student Member............. A. H. Du Boffe

The remainder of the evening was spent in comment on slides of several engineering (?) jobs.

The meeting of April 3, 1917, was called to order by Pres. Schreiber in the engineering rooms. A committee reported that the Summer Camp pictures were being collected and would be framed. A talk by Mr. C. L. Shaw brought out some of the difficulties of engineering problems as typified by the re-building of the Rock Island Bridge at Arsenal Island.

The meeting of April 16th, was for the purpose of explaining the position of the engineer in war. Talks were given by Mr. J. C. Penn and Mr. C. C. Sauer of the City Waterworks Dept., who is captain of Company A, 1st Regiment of Engineers, I. N. G. Rank and pay of the officers and men was stated and the duties of each explained. The talk was a timely one and cleared up many of the puzzling points for the members.

H. W. Stride.

THE FIRE PROTECTION ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President .... A. Corman
Vice-President.............. H. B. Maguire
Secretary .... H. W. Puschel
Treasurer .... L. W. Mattern

On Thursday, April 12, 1917, the Fire Protection Engineering Society had the pleasure of being addressed by Mr. C. G. Kueckler, Examiner, Ins. Co., of North America, the subject being "The Fire Insurance Examiner."

Mr. Kueckler read a paper he had prepared on the subject. He brought out clearly how manifold and complex the duties of an Examiner are, and the responsibility attached to these duties. The Examiner really is the Company's guide. He must know why and how the interests of his individual Company would be affected by the conditions, both morally and physically, inherent to any individual line of business or all combined. He selects the good business from the bad, and in his selection may lead his Company to failure or financial success. The Examiner's position is, no doubt, the most responsible position in the Fire Insurance Office. This gives a few of the important points brought out in Mr. Kueckler's interesting paper, printed copies of which he distributed among the members.

After the reading of the paper, the meeting was open for questions. Many questions were asked. Mr. Kuckler answered them in such a way that the men present received a great deal of additional information concerning the inner-workings of the Fire Insurance business. He also had a number of copies of insurance maps with him and explained the various symbols and how the Examiner made use of them. Thus we practically had two lectures in one evening.

This, no doubt, was the most interesting meeting the society has yet held and the members present felt that it was most excellent for the amount of information gained. We extend our hearty thanks to Mr. Kueckler for preparing such an excellent lecture and also for his kindness in having printed copies made for the members. We hope that he may be with us again in the near future.

Copies of Mr. Kueckler's paper on "The Fire Insurance Examiner" may be obtained from Mr. Corman.

H. W. Puschel.

THE CHEMICAL ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President........................A. H. Smith
Vice-President....................D. E. Cable
Secretary........................A. G. Fitzner
Treasurer........................O. L. Hailey

The Chemical and the Fire Protection Engineering Societies met in a joint session on March 8th, 1917, to hear Mr. Munn speak on chemical hazards. Mr. Munn covered the main points which must be investigated to determine the relative fire hazards of various substances. The points taken up under gaseus, liquid, and solid substances were as follows:

1. The flash point. This tells more than any one test, it being the temperature at which a liquid will give off a sufficient quantity of gas or vapor to ignite with air, the temperature being high enough to cause combustion.

2. Volatility. If the vapor burns the liquid must be volatile. This test of course only applies to hazardous liquids and as the volatility of other liquids does not mean liability to combustion this test is sufficient for our purposes.

3. Heat of combustion. It is necessary not only to know the heat of combustion but also the rapidity of burning and vapor pressure.

4. The ignition point is also a very important test and it is the temperature to which we must heat our liquid in air to produce ignition.

5. Vapor Density is important as those liquids whose vapors are heavier than air are especially dangerous.

6. Spontaneous combustion. Is the substance one which will oxidize rapidly enough under ordinary conditions to cause combustion?

The above tests will give a very good means of determining whether the substance under consideration is hazardous or not. However it must be remembered that no one test is sufficient evidence and furthermore the same tests made by different operators will vary depending upon conditions. In other words the tests are not absolute and standardization by specifying all variable conditions is the only remedy.

Although the lecturer presented very little that was new to us in the way of theoretical considerations, yet the means employed in practice and the indefinite character of the tests showed us the possibilities in the way of improvements.

A. G. Fitzner.

ARMOUR INSTITUTE OF TECHNOLOGY LIBRARY BOOKS ON MILITARY SCIENCE

Andrews, L. C. Fundamentals of military service. Philadelphia, J. B. Lippincott Co., 1916.

Bolles, F. C.; Jones, E. C. & Upham, J. S. The soldier's catechism. Garden City, N. Y., Doubleday Page and Co., 1916.

Bond, P. S. The engineer in war. New York, McGraw-Hill Book Co., 1916.

Bond, P. S. & McDonough, M. J. Technique of modern tactics. Menasha, Wis., Banta Publishing Co., 1914.

Carter, W. H. The American army. Indianapolis, Bobbs-Merrill Co., 1915.

Cole, E. T. & Stuart, E. R. Individual and combined military sketching. Fort Leavenworth, Kansas, Army Service Schools, 1907.

Ellis, O. O. & Garey, E. B. Plattsburgh manual. New York, Century Co., 1917.

Engineer field manual (Professional papers, No. 29, Corps of Engineers, U. S. Army). Washington, D. C.

Kerrick, H. S. Military and naval America. Garden City, N. Y., Doubleday Page and Co., 1916.

Moss, J. A. Manual of military training. Menasha, Wis., Banta Publishing Co., 1914.

Moss, J. A. Officers' manual. Menasha, Wis., Banta Publishing Co., 1916.

Moss, J. A. & Stewart, M. B. Self-helps for the citizen soldier. Menasha, Wis., Banta Publishing Co., 1916.

Robinson, E. F. Military preparedness and the engineer. New York, Clark Book Co., 1916.

U. S. Army Service Schools. Studies in minor tactics, 1915. Fort Leavenworth, Kansas, 1915.

U. S. General Staff. Tables of organization, 1914, U. S. Army. Washington, 1914.

U. S. War Department. Field service regulations, U. S. Army. Washington, 1916.

U. S. Department. Infantry drill regulations. New York, Army and Navy Journal, 1916.

Wood, Leonard. Our military history. Chicago, Reilly and Britton, 1916.

THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.

Edited by the Publication Committee of the Armour Alumni Association.

F. G. Heuchling F. T. Bangs W. H. Lautz

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THE SPRING REUNION

The Board of Managers of the Alumni Association at a recent meeting drew up plans for the annual spring reunion. Last year, it will be remembered, the meeting was held during Junior Week—on Circus Day—and it was such an enjoyable success that it was decided to hold this year's meeting during Junior Week. The date is Thursday, May 10.

The custom of holding the Spring meeting at the Institute, established some time ago, gains greater popularity year by year and has met the hearty approval of the graduates interested in Alumni Association affairs who can and do make their annual visit to the Alma Mater in a body. Setting the date during Junior Week has its advantages, because it links together some of the activities of alumni and under-graduates. It gives the Senior a chance to get a slant at a representative gathering of the men who are out of school and whose ranks he is about to join. Likewise the alumni have the opportunity of seeing, meeting and welcoming the graduating class.

The afternoon circus performance will begin at 3 o'clock and all alumni who can take an afternoon off will find it worth while

to wend their way towards Ogden Field to see the Juniors in their three-ring affair.

The banquet will be held in the gymnasium at 6:30 p. m. Preparations are being made for entertainment by E. H. Freeman, Master of Ceremonies, and announcements of the complete program will be mailed to all alumni in a few days. The price per plate probably will be $1.25.

Remember the date—May 10—afternoon and evening. If you can't come in time for the Circus, at least don't miss the banquet.

ALUMNI NOTES

F. C. Zanzig, '09, is now electrical engineer, Wisconsin Telephone Company, Milwaukee.

H. S. Katz, '16, now H. S. Harris, is employed by the Fort Wayne Works of the General Electric Company, Fort Wayne, Ind.

E. C. White, '99, who conducted a lighting-fixture business in Montreal, Can., has returned to Chicago, and is now president of the Duplex Lighting System, 122 South Michigan Avenue.

George C. Erickson, '12, is sales manager and a stockholder of the Perfection Storage Battery Company and the Dealers' Electric Lighting Company, 2903 Indiana Avenue, Chicago, and is also connected with the Central States Electric Lighting Company, Lincoln, Neb. The latter company operates in Nebraska, Kansas, Iowa and South Dakota.

E. E. Edgecomb, '03, is now assistant branch manager of the Prest-O-Lite Company, Inc., at Indianapolis, Ind.

John E. Lanning, '03, is assistant chief engineer of the El Paso Smelting Works, El Paso, Tex.

Ellis Soper, '09, who was located at Chattanooga, Tenn., for some years, now holds an important position with the Cuban Portland Cement Company, Mariel, Cuba.

Edgar A. Fry, '16, is rodman in the Waterpipe Extension Department, City of Chicago.

Louis Cohen, '01, consulting engineer, 1656 Euclid Street, Washington, D. C., and member of the faculty of George Washington University, was recently granted United States letters patent No. 1,220,072 on a method of wireless signaling. The patent covers an arc system for radio signaling comprising an

antenna circuit and an absorption circuit in parallel with it, and an electrolytic means of varying the resistance of the absorption circuit to thereby vary its electrical time constant and thus vary the amount of current flow in the antenna circuit.

A. P. Strong, '09, superintendent of the department of ash-hauling construction, Green Engineering Company, East Chicago, Ind., has been working on the steam-jet method of pneumatic handling of ashes and recently made developments that assure wide commercial usage of the method. The systems will be designed and manufactured by the Green Engineering Company under United States patents.

OFFICERS NOMINATED FOR 1917-18

The nominating Committee appointed by the Alumni Association has made up the following slate for consideration at the May meeting of the Association:

President, Grover Keeth, '06.

Vice-President, E. C. White, '99.

Recording Secretary, J. N. Byanskas, '16.

Corresponding Secretary, J. J. Schommer, '12.

Treasurer, H. L. Nachman, '02.

Master of Ceremonies, M. S. Flinn, '04.

Member of Board of Managers to fill vacancy caused by E. F. Hiller's resignation, E. G. Hindert, '98.

Members of the Board of Managers to serve until 1920: R. M. Henderson, '02; W. J. Baer, '10, and B. S. Carr, '15.

The committee nominates two of the present list of officers: President Henderson to serve a three-year term on the Board of Managers, and Grover Keeth, now vice-president, to become president. Both have been very active in Association affairs during the year and their retention should meet with the hearty endorsement of the Association.

The committee, in naming a corresponding secretary and a treasurer, selected J. J. Schommer and H. L. Nachman, both members of the faculty, because the work of the two officers has much in common, and, being at the Institute, they should be able to co-operate much more effectively than could a faculty member as corresponding secretary and a graduate in the business world as treasurer. The latter arrangement has been the custom, and much lost motion has resulted in former years.

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